SOE 4: Poster

Time: Monday 17:00–19:00 Location: P2/OG2

SOE 4.1 Mon 17:00 P2/OG2

Identifying subdominant collective effects in a large motorway network — •Shanshan Wang, Michael Schreckenberg, and Thomas Guhr — Faculty of Physics, University of Duisburg-Essen, Duisburg, Germany

In a motorway network, correlations between parts or, more precisely, between the sections of (different) motorways, are of considerable interest. Knowledge of flows and velocities on individual motorways is not sufficient, rather, their correlations determine or reflect, respectively, the functionality of and the dynamics on the network. These correlations are time-dependent as the dynamics on the network is highly non-stationary. Apart from the conceptual importance, correlations are also indispensable to detect risks of failure in a traffic network. Here, we proceed with revealing a certain hierarchy of correlations in traffic networks that is due to the presence and to the extent of collectivity. In a previous study, we focused on the collectivity motion present in the entire traffic network, i.e. the collectivity of the system as a whole. Here, we manage to subtract this dominant effect from the data and identify the subdominant collectivities which affect different, large parts of the traffic network. To this end, we employ a spectral analysis of the correlation matrix for the whole system. We thereby extract information from the virtual network induced by the correlations and map it on the true topology, i.e. on the real motorway network. The uncovered subdominant collectivities provide a new characterization of the traffic network. We carry out our study for the large motorway network of North Rhine-Westphalia (NRW), Germany.

SOE 4.2 Mon 17:00 P2/OG2

Feasibility and goodness of bimodal on-demand public transportation. — •Puneet Sharma, Knut Heidemann, Helge Heuer, Steffen Muehle, and Stephan Herminghaus — Max Planck Institute for Dynamics and Self Organization, Goettingen

Decarbonization of passenger transport is essential for fighting climate emergency. While modern cities offer various modes of transportation, considered separately, none of them is both, sustainable and convenient. A taxi service is convenient, in a sense, due to door-to-door service, but is inefficient since it usually serves one customer only. Demand-responsive ridepooling (DRRP) with minibuses is more efficient, but leads to undue competition with line services (LS), which provide even better pooling but are less convenient due to fixed routes and stops. A combination of both modes, DRRP and LS, may provide an ideal solution but is challenging to organize. Here we introduce a model for such bimodal on-demand transportation based on a square-grid geometry. Our model quantifies under what circumstances bimodal public transportation is feasible, both in terms of convenience and ecological footprint. Moreover, the model yields estimates for how to operate (LS frequency, modal split) a bimodal transportation system optimally. Perhaps surprisingly, we find that operating LS at maximum capacity is not necessarily optimal. We also consider the intricate interplay between LS operations and DRRP performance, i.e., detours, waiting times, and occupancy, via simulations.

SOE 4.3 Mon 17:00 P2/OG2

Just in time vs. all in sync: an analysis of two types of synchronization in a minimal model of machine activity in industrial production based on excitable dynamics on graphs — •Sanghita Bose[1], Annick Lesne[2,3], Julia Arlinghaus[4], and Marc-Thorsten Hütt[1] — [1]Department of Life Sciences and Chemistry, Jacobs University Bremen, Germany — [2]Institut de Génétique Moléculaire de Montpellier, University of Montpellier, CNRS, F-34293, Montpellier, France — [3]Sorbonne Université, CNRS, Laboratoire de Physique Théorique de la Matière Condensée, LPTMC, F-75252, Paris, France — [4]Otto-von-Guericke University Magdeburg, Universitätsplatz 2, 31904, Magdeburg, Germany.

The notion of synchronization in logistics is distinct from that encountered in the natural sciences, and in particular, in physics. In logistics, synchronization is often associated with a 'just in time' paradigm in supply and production systems. A perfect synchronization therefore is that the arrival (of goods at a warehouse or parts at a machine) is a cue for a subsequent transportation or manufacturing event. Globally, this type of synchronization can be envisioned as a wave of activity running through a distribution network or a production network. Here our goal is a deeper theoretical understanding of these two types of synchronization, the one from logistics and the one from physics, as well as their interplay in the context of production systems. We employ a minimal model of propagating excitations (representing machine activity) in a graph (representing a production network).

SOE 4.4 Mon 17:00 P2/OG2

Impact of interactions between layers on source localization in multilayer networks — Robert Paluch, Łukasz Gajewski, •Krzysztof Suchecki, and Janusz Hołyst — Faculty of Physics, Warsaw University of Technology, Koszykowa 75, Warsaw, 00-662, Poland

Nowadays, it is not uncommon to have to deal with dissemination on multilayered networks, and often finding the source of said propagation can be a crucial task. We examine the issue of locating the source of Susceptible-Infected spreading process in a multilayer network using the Bayesian inference and the maximum likelihood method established for general networks and adapted here to cover multilayer topology. We show how its accuracy depends on the network and spreading parameters and find the existence of two parameter ranges with different behavior. If the inter-network spreading rate is low, observations in different layers interfere, lowering accuracy below that of relying on single-layer observers only. If it is high, on the other hand, observations synergize, raising accuracy above the level of a single-layer network of the same size and observer density. We also show a heuristic method to determine the case in a system and potentially improve accuracy by rejecting interfering observations.

SOE 4.5 Mon 17:00 P2/OG2

Mean field approach for link coupling in Heider dynamics in bilayer network — •Krishnadas Mohandas and Janusz Hołyst — Warsaw University of Technology, Poland

Structural balance was observed in many social groups with simultaneous friendly and hostile relations. Frequently these interactions need to be described by muticomponent attributes and different components can be coupled together. In this study we consider a bilayer topology of Heider balance in a link multiplex, a unique multiplex in which coupling not only exists between different agents but also between corresponding links of the same agent. In social networks, for instance, agents can belong to the family, professional and friends group, where links in each layer could address either sports or politics. The dynamics of agents differs inside and between the layers and the coupling coefficients between the layers govern the strength of influence of one link-layer on another. Numerical simulations and analytical calculations using heat-bath approach and mean-field approximation demonstrate that the link polarization for both layers of a complete signed network of N agents tends towards Heider balance below critical temperature. The effect of such inter-layer coupling results in the increase of critical temperature with the strength of positive coupling. Periodical and chaotic trajectories of mean polarisations of both components are observed for a range of temperatures in the case of negative interlayer coupling.

SOE 4.6 Mon 17:00 P2/OG2

Counting Graphs and Molecules — •Rana Shojaei[1,2,3] and Thilo Gross[1,2,3] — [1]Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg (HIFMB), Oldenburg, Germany — [2]Alfred Wegener Institute- Helmholtz Centre for Marine and Polar Research, Bremerhaven, Germany — [3]Carl von Ossietzky University- Institute for Chemistry and Biology of the Marine Environment (ICBM), Oldenburg, Germany

Counting the number of simple graphs that can be constructed between a given number of unlabeled (indistinguishable) nodes is a long-standing challenge. We consider this problem using Polya's counting theory. For illustration, we first consider a related problem that has historically received much attention: counting the number of chemical molecules with a given number of atoms. Indeed, it was in the context of this problem that the term 'graph' was first coined. Application of the same principles and procedure leads to a simple closed-form formula for the number of simple graphs, however, the efficient evaluation of the formula for large graphs remains an open problem.

SOE 4.7 Mon 17:00 P2/OG2

How random are team sports leagues? — Maciej Pawlik[1], Michał Boruta[2], Robert Paluch[1], and •Janusz Hołyst[1] — [1]Faculty of Physics, Warsaw University of Technology, Warsaw, 00-662, Poland — [2]Faculty of Mathematics and Information Science, Warsaw University of Technology, Warsaw, 00-662, Poland

To answer the title question, the historical ranking tables of four team sports leagues (Premier League, Bundesliga, La Liga, Svenska Hockeyligan) are analyzed. We investigate the predictability level of a given league by calculating the average absolute rank change $\overline{\rho}$ between two subsequent seasons of every team. The data are applied to calibrate an agent-based model of team sports leagues where every team possesses a certain strength equal to the sum of strengths of all players that have been selected to the team from a draft list. The sign of the difference between the strengths of two teams indicates the favorite of a given game, and there is a determinism parameter $\beta \in (0, \infty)$ that controls the game predictability. We use the model to simulate many seasons of various leagues and to compute the average absolute rank change $\overline{\rho}$ of a given team between two consecutive seasons. Plotting $\overline{\rho}$ as a function of β reveals a continuous transition between phases of luck– and skill–based sports. Comparing the results of our model with the ranking tables of selected professional leagues, we show that they operate close to the transition line but in the deterministic phase. This finding suggests that random factors and abilities of team players are of comparable importance, with an advantage of the latter.

SOE 4.8 Mon 17:00 P2/OG2

Simulating neutral biodiversity in large-scale networks — •Jeffrey Kelling[1,2], Richa Tripathi[3], and Justin M. Calabrese[3] — [1]Helmholtz-Zentrum Dresen-Rossendorf, Dresden, Germany — [2]Chemnitz University of Technology, Chemnitz, Germany — [3]Center for Advanced Systems Understanding (CASUS), Helmholtz-Zentrum Dresen-Rossendorf, Görlitz, Germany

The neutral model of biodiversity describes a Markov process of death and replacement of neutral individuals constituting the species occupying an ecosystem. It predicts a number macroscopic ecosystem observables, including local and global abundances, and can serve as advanced null-hypothesis for more complex models. We present a massively parallel approach to simulating the neutral model which both enables simulations on large networks, to, e.g., capture fine details of real river networks, and efficiently produces averages results to enable comparisons with empirical data or other models at high statistical significance or accurately compute correlations or responses.

SOE 4.9 Mon 17:00 P2/OG2

A toy model for the rise and collapse of societies — •Alexander Jochim and Stefan Bornholdt — Institute for Theoretical Physics, University of Bremen

Societal collapse as in ancient Rome is rather common than an exception along history. Similar patterns can be observed along time and space, and modern societies are potentially as vulnerable. Relying on empirical data, recent work has introduced mathematical models for long term processes in society. Here we report on a simple, physics-inspired model that exhibits metastable states and phases of collapse or sustained prosperity

SOE 4.10 Mon 17:00 P2/OG2

The Verification Dilemma in computer security: a game-theoretic perspective — •Jens Christian Claussen and Aad van Moorsel — School of Computer Science, University of Birmingham, UK

Verification protocols, as the Proof-of-Work (PoW) in blockchains, are essential mechanisms to ensure security in distributed networks. The computational costs of verification can also be organized in a shared way through special users, called miners. It has been pointed out that a Verifier's Dilemma arises between verifying and non-verifying miners [1]. Here we analyze the verification problem from game theory, identifying it as a strategic dilemma similar to a public goods game.

[1] D. Smuseva, I. Malakhov, A. Marin, A. van Moorsel and S. Rossi, Verifier's Dilemma in Etherum Blockchain: A Quantitative Analysis, LNCS 13479, 317 (2022)

SOE 4.11 Mon 17:00 P2/OG2

Investigating the Impacts of Regulatory Changes in Energy Systems with Explainable Artificial Intelligence — •Sebastian Pütz[1], Dirk Witthaut[2,3], and Benjamin Schäfer[1] — [1]Institute for Au- tomation and Applied Informatics, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany — [2]IEK-STE Research Centre Jülich, Jülich, Germany — [3]University of Cologne, Cologne, Germany

The stable supply of electrical energy is essential for the functioning of our society. Therefore, the operation of the electrical power grid and its related markets is subject to strict regulations. As the external technical, economic or social influences on the power grid change permanently, e.g. due to the energy transition, these regulations must also be constantly adapted. It is important to find out whether the regulatory changes lead to the intended results or whether they entail undesired side effects. We investigate regulatory changes using a data-driven approach based on publicly available techno-economic data on European power grids and electricity markets. We employ explainable machine learning models to identify important dependencies and disentangle the interaction of individual features. Using additive Shapley explanations, we identify changes due to the introduction of the 'Mischpreisverfahren' in the German balancing energy market or the splitting of the German-Austrian bidding zone.

SOE 4.12 Mon 17:00 P2/OG2

Delay Dynamics in a Nonlinear Economic Model — •Sándor Kovács[1], Szilvia György[1], Júlia Tompa[2], and Noémi Gyúró[2] — [1]Department of Numerical Analysis, Eötvös LorándUniversity, \\ Pázmány Péter sétány 1/C, H-1117 Budapest, Hungary\\ E-mail: alex@ludens.elte.hu — [2]Eötvös Loránd University, \\ Pázmány Péter sétány 1/C, H-1117 Budapest, Hungary

This talk is about the qualitative behavior of an economic model proposed by D. Meyer (cf. [1]). It is shown that under certain conditions on the parameters the system has uniformly bounded and no nontrivial periodic solutions. Subsequently, a possible equilibrium on the boundary of the positive phase space not discussed in [1] was founded and showed that if there is no interior equilibrium, then the equilibrium at the boundary will become unstable, whereas the equilibrium at the boundary will be stable. In order to have more realism, two types of delay will be introduced: an infinite distributed delay and a discrete delay. It is shown that contrary to the result in [1] the distributed delay does not change the stability of the equilibrium points. Finally, by introducing a discrete delay, it was showed that at a certain parameter value Hopf bifurcation takes place: periodic solutions arise. [1] Meyer, D. Equity and Efficiency in Regional Policy. Periodica Mathematica Hungarica Vol. 56 (1), 2008, 105*119.

SOE 4.13 Mon 17:00 P2/OG2

A model of public opinion with time-dependent media influence, audience attention and social influence. — •Michael Schnabel[1] and Daniel Diermeier[1,2] — [1]Vanderbilt University, Department of Political Sciences, Nashville, TN, USA — [2]Vanderbilt University, Owen School of Management, Nashville, TN, USA

We consider a simple model of binary opinions. Individuals form their opinions based on individual preferences, time-dependent media influence and the overall opinions in the population. In addition, we also incorporate a mechanism that is responsive to the salience of the media influence and can be used to account for variations in public attention. We explore how attention affects the opinion dynamics in the population as well as the equilibrium properties in a hypothetical quasi-static environment. Our model can account for populations with heterogeneous preferences and can also be used to examine the dynamics of opinion polarization within a population.

SOE 4.14 Mon 17:00 P2/OG2

Analysis of changes of opinions and social network structure of NetSense experiment participants — •Bartłomiej Zwoliński and Piotr Górski — Faculty of Physics, Warsaw University of Technology, Warsaw, 00-662 Poland

We study the interrelation between interactions and opinions by using data on Bluetooth contacts between college freshmen. We research evolution of social network structure and their opinions on eight topics within two-year period.

We find weak but significant correlation between students' vectors of opinions and their further interactions. Higher number of interactions had different impact on students' opinions depending on the period of the study, polarising them or leading to opinion alignment.

Throughout the experiment, we observed change of the students' contact network from overall community to smaller groups worse interconnected with each other.