SOE 4: Data Analytics for Complex Dynamical Systems (joint SOE/DY Focus Session) (joint session SOE/DY)

Time: Tuesday 11:00–12:40 Location: SOEa

SOE 4.1 Tue 11:00 SOEa

Network inference from event sequences: Disentangling synchrony from serial dependency — •Reik Donner[1,2], Adrian Odenweller[2], Frederik Wolf[2], and Forough Hassanibesheli[2] — [1]Magdeburg-Stendal University of Applied Sciences, Magdeburg, Germany — [2]Potsdam Institute for Climate Impact Research (PIK) - Member of the Leibniz Association, Potsdam, Germany

Inferring coupling among interacting units or quantifying their synchronization based on the timing of discrete events has vast applications in neuroscience, climate, or economics. Here, we focus on two prominent concepts that have been widely used in the past: event synchronization (ES) and event coincidence analysis (ECA). Numerical performance studies for two different types of spreading processes on paradigmatic network architectures reveal that both methods are generally suitable for correctly identifying the unknown links. By further applying both concepts to spatiotemporal climate datasets, we demonstrate that unlike ECA, ES systematically underestimates linkages in the presence of temporal event clustering, which needs to be accounted for in network reconstruction from data. In turn, for spike train data from multi-channel EEG recordings (with relatively narrow inter-event time distributions), the obtained results are practically indistinguishable. Our findings allow deriving practical recommendations for suitable data preprocessing in the context of network inference and synchronization assessment from event data.

SOE 4.2 Tue 11:20 SOEa

Identification of Stochastic Differential Equations from Data — •Tobias Wand[1] and Oliver Kamps[2] — [1]Westfälische Wilhelms-Universität Münster — [2]Center for Nonlinear Science Münster

In recent years, methods to identify dynamical systems from experimental or numerical data have been developed [1, 2]. In this context, the construction of sparse models of dynamical systems has been in the focus of interest and has been applied to different problems. These data analysis methods work with hyper-parameters that have to be adjusted to improve the results of the identification procedure. Nondeterministic systems require a refined identification algorithm. In this talk, we will introduce an approach to optimally select hyperparameters for the identification of sparse differential equations from non-deterministic data.

[1] Brunton et al. Proceedings of the National Academy of Sciences, 2016, 113, 3932-3937

[2] Mangan et al. Proceedings of the Royal Society A, 2017, 473, 20170009

SOE 4.3 Tue 11:40 SOEa

Data-driven analysis of the power grid frequency — •Benjamin Schäfer[1], Christian Beck[1], Leonardo Rydin Gorjão[2,3], Johannes Kruse[2,3], and Dirk Witthaut[2,3] — [1]School of Mathematical Sciences, Queen Mary University of London, London E1 4NS, United Kingdom — [2]Forschungszentrum Jülich, Institute for Energy and Climate Research-Systems Analysis and Technology Evaluation (IEK-STE), Jülich, Germany — [3]Institute for Theoretical Physics, University of Cologne, Köln, Germany

The Paris conference 2015 set a path to limit climate change to "well below 2°C". To reach this goal greenhouse gas emissions have to be reduced and renewable generators, electrical mobility or smart grids are integrated into the existing power system.

The introduction of these new technologies raises several questions about control, stability and operation and therefore requires a solid understanding of existing and future systems and new conceptional approaches.

Here, we use data-driven approaches to work towards a quantitative understanding of the power grid with a particular focus on the power grid frequency. We analyse time series from various synchronous areas such as Continental Europe, Great Britain but also two US areas and several European islands.

We highlight significant deviations from Gaussianity in several regions, scaling laws and spatio-temporal dynamics. Finally, we discuss how past information may be used to forecast the frequency.

SOE 4.4 Tue 12:00 SOEa

Tipping and transition paths in high-dimensional agent-based models — •Luzie Helfmann[1,2,3], Peter Koltai[1], Jobst Heitzig[3], and Christof Schütte[2,1] — [1]Freie Universität Berlin — [2]Zuse Institute Berlin — [3]Potsdam Institute for Climate Impact Research

Agent-based models are a popular choice for modeling complex social systems. Here, we are concerned with studying noise-induced tipping between relevant subsets of the agent state space, e.g., in order to understand drastic opinion changes in a population of agents. Due to the large number of interacting individuals, agent-based models are usually very high-dimensional. We therefore apply Diffusion Maps, a non-linear dimension reduction, to reveal the intrinsic low-dimensional structure of the model dynamics. We will characterize the tipping behavior by means of Transition Path Theory, a theory for gaining statistical understanding of the tipping paths (e.g., their density, flux, rate). We will illustrate our approach on two examples, both exhibiting a multitude of tipping pathways.

SOE 4.5 Tue 12:20 SOEa

Quasi-stationary states in temporal correlations for traffic systems: Cologne orbital motorway as an example — •Shanshan Wang, Sebastian Gartzke, Michael Schreckenberg, and Thomas Guhr — Fakultät für Physik, Universität Duisburg–Essen, Lotharstraße 1, 47048 Duisburg, Germany

Traffic systems are complex systems that exhibit non-stationary characteristics. Therefore, the identification of temporary traffic states is significant. In contrast to the usual correlations of time series, here we study those of position series, revealing structures in time, i.e. the rich non-Markovian features of traffic. Considering the traffic system of the Cologne orbital motorway as a whole, we identify five quasi-stationary states by clustering reduced-rank correlation matrices of flows using the k-means method. The five quasi-stationary states with nontrivial features include one holiday state, three workday states and one mixed state of holidays and workdays. In particular, the workday states and the mixed state exhibit strongly correlated time groups shown as diagonal blocks in the correlation matrices. We map the five states onto reduced-rank correlation matrices of velocities and onto traffic states where free or congested states are revealed in both space and time. Our study opens a new perspective for studying traffic systems. This contribution is meant to provide a proof of concept and a basis for further study.