SOE 11: Traffic Dynamics, Urban and Regional Systems II

Time: Wednesday 16:45–18:15 Location: ZEU 260

SOE 11.1 Wed 16:45 ZEU 260

Response functions as a new concept to study local dynamics in traffic networks — •Shanshan Wang, Michael Schreckenberg, and Thomas Guhr — Faculty of Physics, University of Duisburg-Essen, Duisburg, Germany

Vehicle velocities in neighbouring road sections are correlated with memory effects. We explore the response of the velocities in the sequence of sections to a congestion in a given section and its dynamic characteristics. To this end, we transfer the concept of response functions from previous applications in finance to traffic systems. The dynamical characteristics are of particular interest. We identify two phases, a phase of transient response and a phase of long-term response. The transient response is pronounced when considering the backward propagation of heavy congestions but almost vanishes for forward propagation. For each response phase, we find a linear relation between the velocity response and the congestion correlator, implying that the correlation of congestion is most likely the cause for the velocity response. We also construct a susceptible-decelerated-withdrawing model mathematically inspired by the susceptible-infectious-recovered (SIR) model in epidemiology to describe the transient response. We find that the heavy congestion on a section propagates forward and backward at a similar rate, but the forward sections are more likely to recover from the effect of heavy congestion than the backward sections.

SOE 11.2 Wed 17:00 ZEU 260

A Fast and Modular Framework for Simulating Ridepooling Systems — •Felix Jung[1], Debsankha Manik[1], and Marc Timme[1,2] — [1]Chair for Network Dynamics, Institute of Theoretical Physics & Center for Advancing Electronics Dresden (cfaed), TU Dresden, 01062 Dresden, Germany — [2]Lakeside Labs, Klagenfurt, Austria

Climate change and congested cities urgently call for a transformation of passenger road transport that today still largely relies on flexible but inefficient private cars. Ridepooling services may reduce the environmental impact while maintaining a high level of flexibility. They move passengers between arbitrary locations, ideally on-demand and on short notice, while dynamically combining trips of several passengers into the same vehicle. However, under which conditions these services are simultaneously efficient, sustainable, and performant is not well understood to date.

Most research into such questions primarily relies on extensive computer simulations, because real-world experiments are extremely expensive and may negatively influence user adoption. Existing simulation tools have a much broader scope but are hard to evaluate with respect to fundamental physical observables, are not sufficiently performant, or hard to use. Here we present a new simulation framework that overcomes these challenges and is easy to use, modular and fast. The framework is released under an Open Source license in the hope that it will benefit the research community and further collaborative development.

SOE 11.3 Wed 17:15 ZEU 260

Service Quality Paradox – Guaranteeing early deliveries causes overall delays in ride pooling services — •Philip Marszal[1,2], Marc Timme[1,2,3], and Malte Schröder[1,2] — [1]Center for Advancing Electronics Dresden (cfaed), Technical University of Dresden, 01062, Dresden, Germany — [2]Institute for Theoretical Physics, Technical University of Dresden, 01062, Dresden, Germany — [3]Lakeside Labs, Lakeside B04b, Klagenfurt, 9020, Austria

On-demand ride pooling services become increasingly important for modern human mobility and rely on advanced forms of dispatching and coordination algorithms [1,2]. A central algorithm matches the vehicles of service providers to the trip requests of customers, aiming to efficiently combine passenger trips in order to reduce service time and distance traveled [3]. Here we reveal a service quality (SQ) paradox emerging emerging from how such services self-organize given a dispatching strategy: enforcing a maximum delay an individual passenger can experience may increase the average delay of all passengers. We quantitatively evaluate the SQ paradox in terms of the vehicle route flexibility, a measure of how many possible passengers may be served by a single vehicle. Our results theoretically revealed conditions underlying the novel paradox and may inform future designs of ridepooling algorithms to improve the service quality of the shared mobility ecosystem.

References: [1] Schröder et al., Nature Comm. 11:4831 (2020). [2] Storch et al., Nature Comm. 12:3003 (2021). [3] Alonso-Mora et al., PNAS 114:426 (2017).

SOE 11.4 Wed 17:30 ZEU 260

Short walks enable fast and sustainable ride sharing — •Charlotte Lotze[1], Philip Marszal[1], Malte Schröder[1], and Marc Timme[1,2] — [1]Chair for Network Dynamics, Institute for Theoretical Physics & Center for Advancing Electronics Dresden (cfaed), Technical University of Dresden, 01069 Dresden — [2]Lakeside Labs, Klagenfurt, Austria

Ride sharing - the bundling of simultaneous trips of several people in the same on-demand vehicle - may help to reduce the carbon footprint of human mobility. Yet, predicting the efficiency and sustainability of ride-sharing systems is hard due to their complex collective dynamics. Compared to individual motorized vehicle transportation, standard door-to-door ride sharing services reduce the total distance driven per user. However, they also increase the average travel times due to several additional stops and thus detours to pick up or drop off users. Here we show that requiring some users to walk to nearby shared stops reduces detours for the buses and thus the time users wait for their bus and drive in the bus. These time savings might overcompensate the additional walk time for the users. In this way, dynamic stop pooling reduces the average travel time and may break the trade-off between distance driven and travel time prevailing in door-to-door ride sharing. For example, ride sharing providers may reduce the fleet size to save distance driven without longer travel times when users walk a short part of their trip. Dynamic stop pooling may thus enable more sustainable ride sharing services without compromising service quality.

SOE 11.5 Wed 17:45 ZEU 260

Long-range correlations in city systems — Yunfei Li[1], Jan W. Kantelhardt[2], Celine Rozenblat[3], and •Diego Rybski[1,4] — [1]Potsdam Institute for Climate Impact Research - PIK, Member of Leibniz Association, P.O. Box 601203, 14412 Potsdam, Germany — [2]Institute of Physics, Martin-Luther-University, Halle (Saale), Germany — [3]Institute of Geography and Sustainability, Faculty of Geoscience, University of Lausanne; — [4]Complexity Science Hub Vienna, Josefstädterstrasse 39, A-1090 Vienna, Austria

City systems are characterized by the functional organization of cities on a regional or country scale. While there is relatively good empirical and theoretical understanding of city size distributions, insights about their spatial organization remain on a conceptual level. Here we analyze empirically the correlations between the sizes of cities (in terms of area) across long distances. Therefore, we (i) define city clusters, (ii) obtain the neighborhood network from Voronoi cells, and (iii) apply a fluctuation analysis along all shortest paths. We find that most European countries exhibit long-range correlations but in several cases these are anti-correlations. In an analogous way we study a model inspired by Central Places Theory and find that depending on the level of disorder, both positive and negative long-range correlations can be simulated. We conclude that the interactions between cities of different sizes extend over distances reaching country scale.

SOE 11.6 Wed 18:00 ZEU 260

Mapping the social structure of cities with Diffusion Maps — •Thilo Gross — Helmholtz Institute for Functional Marine Biodiversity,, Oldenburg, Germany — Carl-von-Ossietzky University, Oldenburg, Germany — Alfred-Wegener Institute, Helmholtz Center for Marine and Polar Research, Bremerhaven, Germany

Human society is aggregating and accelerating, leading to a rapid growth of cities. It is well known that the social structure of cities is important for a long list of reasons, including livability, security, sustainability, and disaster resilience. Analysis of the social structure can profit from two complementary data sources: Census datasets provide a wealth of high quality, highly structured information, but are typically only available once per decade. By contrast novel sources of mobility data (e.g. from phone traces) offer an unstructured and indirect, but rich and near-real-time glimpse of human social behavior. In this talk I illustrate how diffusion maps, a network-driven analysis method, reveal important patterns in both of these types of data.