SOE 12: Urban Systems and Traffic Flow

Time: Wednesday 10:00–11:00 Location: MA 001

SOE 12.1 Wed 10:00 MA 001

Analytical and numerical treatment of the every-pair-interaction problem — Fabiano L. Ribeiro[1], Yunfei Li[2], Stefan Born[3], and •Diego Rybski[2] — [1]Department of Physics (DFI), Federal University of Lavras (UFLA), Lavras MG, Brazil — [2]Potsdam Institute for Climate Impact Research (PIK), P.O. Box 601203, 14412 Potsdam, Germany — [3]Technische Universität Berlin, Chair of Bioprocess Engineering and Institute of Mathematics, Strasse des 17. Juni 135, 10623 Berlin, Germany

We systematically treat every-pair interactions (a) that exhibit power-law dependence on the Euclidean distance and (b) act in structures that can be characterized using fractal geometry. We analytically derive the mean interaction field of the cells and find that (i) in a long-range interaction regime, the mean interaction field increases following a power-law with the size of the system, (ii) in a short-range interaction regime, the field saturates, and (iii) in the intermediate range it follows a logarithmic behavior. For long-range interactions, the theoretical calculations align closely with the numerical simulations. For short-range interactions, we observe that discreteness significantly affects the results, which requires an expansion that substantially improves the accuracy of the analytical expression. We conclude with applications. Early version of the respective manuscript: https://arxiv.org/abs/2307.07783

SOE 12.2 Wed 10:15 MA 001

Coherent Economic Paths in Urban Systems Development — •Simone Daniotti — Complexity Science Hub, A-1090 Vienna, Austria

Diversity is pivotal for local economic development, shielding economies from sector-specific shocks and fostering innovation. However, maintaining diversity requires a widening capability base in cities. While economic geography literature explores the consequences of urban diversity, limited research addresses the constraints on diversity. This paper aims to address this gap by introducing a measure of coherence in economic activities, assessing the technological or cognitive distance between workers in a city. Examining US cities from 1850 to 1930 and recent periods (2002-2022 for occupations and patents, and 1980-2020 for technological specializations), the study reveals that, despite rapid specialization changes, the average coherence across urban systems remains stable. Interestingly, coherence falls by 4% with city size, regardless of the dataset or period, indicating a consistent correlation between city size and distinctive developments. While the reasons for this pattern remain unclear, the findings emphasize the significant relationship between city size and the observed extent of distinctiveness or dissimilarity in their specialized developments.

SOE 12.3 Wed 10:30 MA 001

Fast & Furious: Extreme events and non-Gaussian velocities in urban car traffic — Moritz Piepel[1], •Malte Schröder[1], Angelika Hirrle[2], and Marc Timme[1,3] — [1]Chair for Network Dynamics, Institue for Theoretical Physics and Center for Advancing Electronics, TUD Dresden University of Technology — [2]Chair of Traffic Process Automation, Institute of Traffic Telematics, TUD Dresden University of Technology — [3]Lakeside Labs, Klagenfurt

The majority of traffic flow models and observations focus on traffic dynamics on highways, assuming Gaussian velocity distributions typically observed in time-aggregated measurements. Here, we analyze individual velocity measurements in urban car traffic based on 145 induction loop detectors throughout the city of Dresden, observing over 340 million vehicle velocities in total. We find that velocity distributions in urban traffic are non-Gaussian, with frequent extreme velocities, independent of the local speed limit. Gaussian distributions significantly underestimate the frequency of extreme velocities and their consequences. For example, the number of speeding violations observed in the data would be valued in fines of 800 million Euros annually, more than 300 times the actual fines collected in Dresden. These observations seem to be generic and are confirmed by data on speeding violations in the city of Cologne. Our findings shed a new light on urban traffic modeling and may have implications for road safety regulations, the design of road infrastructure, and speed limits to ensure safe urban mobility.

SOE 12.4 Wed 10:45 MA 001

Electrical potential mapping of urban human flow: a river basin validation study — •Yohei Shida[1,2], Hideki Takayasu[2,3], and Misako Takayasu[3] — [1]University of Tsukuba, Tsukuba, Japan — [2]Tokyo Institute of Technology, Yokohama, Japan — [3]Sony Computer Science Laboratories, Tokyo, Japan

We conduct a thorough investigation to assess the accuracy and validity of our previously proposed GPS-based human flow potential model, which assembles human mobility using imaginary electric circuits. In contemporary urban studies, a notable approach has emerged, wherein human flow patterns are elucidated through the concept of potential. Despite the initial promise of this approach and similar methodologies, studies are yet to undergo through comprehensive validation.

By employing the river basin analysis approach, we confirm that our potential model adheres to the universal scaling law of human flow. To validate these assertions, we apply river basin analysis to human flow potentials in various Japanese metropolitan areas, utilizing high-resolution human flow data from smartphone users.

The human flows regenerated from the potentials retain the information content of the original human flows, displaying robust agreement in terms of human flow scaling laws during the morning commuter rush, such as the 3D structure of the moving people amount and fractal transportation patterns. Furthermore, by accounting for the influence of daily fluctuations in human flow on the scaling relations, we quantitatively estimate the least number of days required to establish an empirical law for human flow.