



Modeling Dynamic Infrastructure Systems with Spatiotemporal Network Science

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Abstract:

Network science provides powerful methods for analyzing and controlling complex systems across various domains, including power grids, transportation, and communication infrastructures, as well as social and economic networks. With increasing access to spatial-temporal and sequential data, traditional network models based solely on topological relationships are no longer sufficient to capture the intricacies of real-world systems. Data such as traffic flows, power consumption, or supply chains reveal deeper insights into how relationships evolve over time and space, presenting new challenges for analysis.

This presentation will explore formal methods in network science designed to address these challenges, focusing on dynamic processes in transportation networks and multi-layer spatially embedded systems. We will introduce space- and time-aware network analytic techniques that account for both the temporal and topological dimensions of complex systems, providing a comprehensive approach for modeling and controlling these dynamic infrastructures. Through this lens, we aim to bridge the gap between theoretical advancements in network science and their practical application in engineering.

Bio:

Dr. Hackl is an Assistant Professor of Complex Infrastructure Systems at Princeton University's Department of Civil and Environmental Engineering. His research spans the interface between network science and complex infrastructure systems, focusing on spatial-temporal networks, uncertainty quantification, and digital twin technologies. He obtained his PhD from ETH Zürich in 2019 and subsequently served as a senior researcher at the University of Zürich's Department of Computer Science from 2019 to 2022. In 2020, he was appointed as an Assistant Professor at the University of Liverpool, where he focused on urban risk and resilience assessments. Dr. Hackl later joined the University of Cambridge as a Research Assistant Professor for Digital Twins in 2022 before moving to Princeton in 2023.

His work bridges theoretical advancements in network science with practical applications in infrastructure systems, offering insights into dynamic processes in power grids, transportation systems, and multi-layered, spatially embedded networks. A key focus of his research is the quantification and propagation of uncertainties within these complex, interconnected systems, enabling more accurate risk assessments and resilience strategies. This approach is particularly crucial for addressing the impacts of climate change while also fostering integrated solutions to tackle the pressing challenges facing our cities and society.



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1310 Yeh Student Center