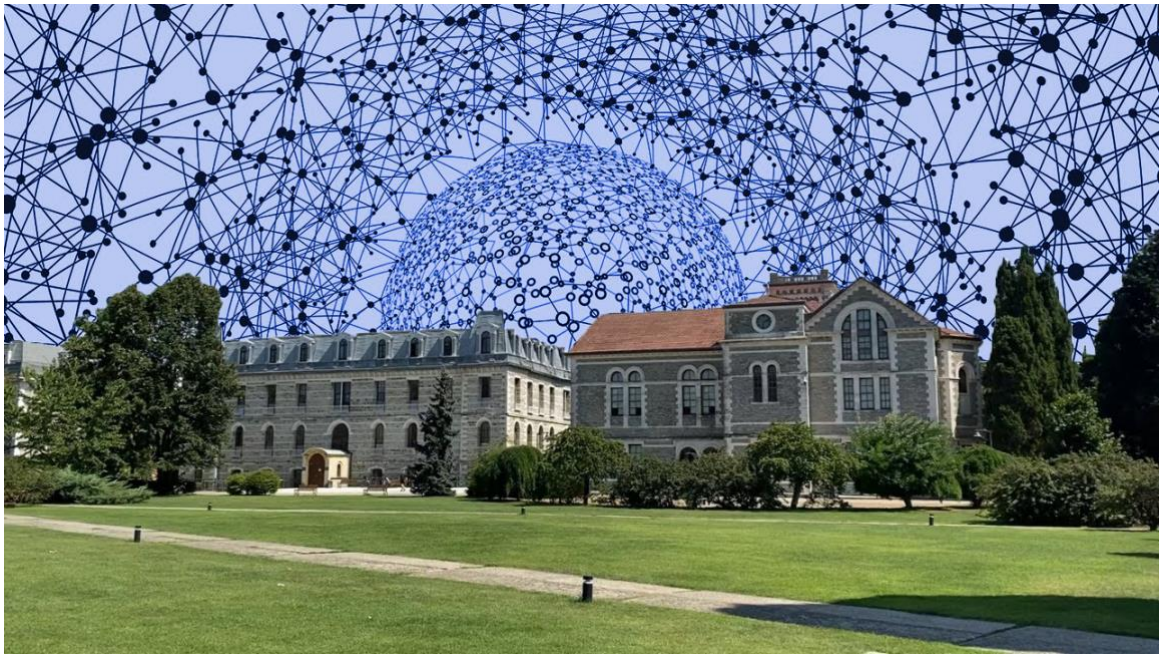
Workshop on Graph Theory and Its Applications (WGT-XII)

ABSTRACT BOOK

24-25 October 2025

Boğaziçi University, Istanbul, Turkey



CONTENTS

Sync

Deniz Eroğlu

deniz@khas.edu.tr

Kadir Has University, Istanbul Turkey - Imperial College London, London, UK

There is a persistent pull toward collective order in nature, yet unpredictability and fragmentation remain deeply embedded. This talk explores how coherence emerges in complex networked systems, with a focus on synchronization phenomena observed across biological, physical, and technological domains. The mathematical foundations of synchrony are outlined, including recent advances in inferring coherent behavior when the underlying dynamics are not explicitly known and must be reconstructed from data. Applications are drawn from power-grid stability, traffic-flow dynamics, and data-driven modeling pipelines that bridge empirical behavior with spectral theory. Particular attention is given to how structural features—such as non-normality and reactivity—critically shape system responses to perturbations. In this regime, subtle shifts in linearized dynamics—often overlooked—can lead to amplified transient responses or unexpected stabilization. This synthesis offers new insights into the geometry of collective response and invites further exploration at the intersection of dynamics, data, and structure.

Complex Networks Perspective on Power Grid Reconstruction and Optimisation

Arash Rezaeinazhad

arashr@khas.edu.tr

Kadir Has University, Istanbul, Turkey

Modern power grids are dynamic flow networks whose topology and physics jointly shape their stability and performance. Rather than relying on restricted or outdated real-world datasets, we introduce a semi-synthetic, reproducible framework that integrates the most recent topological data e.g. from OpenStreetMap, with physical laws such as Kirchhoff's and Ohm's. Parameters are not assumed but inferred by optimising synchronisation in a network of coupled oscillators, yielding grid models that are both physically grounded and dynamically stable. Because our approach treats the grid as a living, evolving system, it supports continuous updates and improvements, enabling robust studies of network resilience, synchronisation and optimisation beyond what is observable in actual infrastructure.

Data-Driven Macroscopic Modeling of Traffic Flow in Network Systems

Toprak Fırat
atoprakfirat@gmail.com
Kadir Has University, Istanbul Turkey

Urban traffic modeling often trades realism for scalability. We introduce a macroscopic, data-driven model that simulates traffic as a discrete-time load-exchange process on networks. Using only network topology, road types, and observed densities, without assuming origin–destination flows, it captures bottlenecks, spillbacks, and adaptive load redistribution. Parameters are fitted via evolutionary optimization, and the model is validated on synthetic grids and real data from London, Istanbul, and New York. The framework provides a scalable and interpretable alternative for urban traffic forecasting with high computational efficiency.

Paleoclimate Networks: Reconstruction and Analysis

Çelik Özdeş
celik.ozdes@khas.edu.tr
Kadir Has University, Istanbul, Turkey

Climate is a complex system characterized by intricate, nonlinear interactions across multiple scales. Investigating past critical transitions in climate is paramount because sudden, large-scale changes can have profound and irreversible consequences for human societies and natural ecosystems. Paleoclimatology studies utilize proxy records preserved in diverse physical forms that yield irregularly spaced time series as measurements. We propose a network framework to investigate climate regime changes via the collected spatial proxy information by encoding a coarse description of the ambient dynamics using functional interaction networks, data-driven conceptual units mimicking the teleconnections in the climate system. We demonstrate that these networks are highly interpretable and representative surrogates for the ambient dynamical conditions, and their transition structure can also mimic the multi-stable behavior of the system.

Properly Colored Hamiltonian Paths in Edge-Colored Complete Bipartite Graphs Without Monochromatic and Semi-Monochromatic C_4

Yasemin Büyükçolak
turediyasemin@gmail.com
Gebze Technical University, Kocaeli, Turkey

A subgraph of an edge-colored graph is called properly colored if no two adjacent edges have the same color. In 1997, Bang-Jensen and Gutin proposed a conjecture that precisely characterizes when an edge-colored complete graph K_n contains a properly colored Hamiltonian path (PCHP). This conjecture was first partially resolved by Barr who proved that the absence of monochromatic triangles is sufficient to ensure the existence of a PCHP. In 2006, it was completely settled by Feng et al., after which it became known as the Bang–Jensen–Gutin (BJG) Theorem.

As a natural bipartite analogue of the BJG Theorem, in 2020, Cheng et al. conjectured that the same characterization of properly colored Hamiltonian paths in complete graphs also holds for complete balanced bipartite graphs. In this work, we initiate the study of this conjecture by establishing a bipartite analogue of Barr's result: the absence of a monochromatic C_4 and a semi-monochromatic C_4 is sufficient to ensure the existence of a PCHP in complete balanced bipartite graphs $K_{n,n}$Furthermore, the constructive character of our result naturally leads to a polynomial-time algorithm capable of finding a PCHP in such graphs.

A stable set based Branch-and-bound Algorithm for the Minimum Spanning Tree Problem with Conflict Constraints

Murat Umur İzer
umutizer@yahoo.com
Boğaziçi University, Istanbul,Turkey

Given a simple graph with nonnegative edge weights and a graph representing conflict relations between the edge pairs, the minimum spanning tree problem with conflict constraints consists of finding a minimum cost spanning tree without any conflicting edge pair. Unlike the ordinary minimum spanning tree problem, this one is known to be NP- hard. We propose a novel branch-and-bound algorithm for the exact solution of the problem. It uses a combinatorial branching rule based on the maximal stable sets of the conflict graph and the information provided by the minimum spanning tree relaxations. According to the results of extensive computational tests, it is possible to say that the new algorithm is very efficient and outperforms a well-known commercial mixed-integer linear programming software.

Moment Analysis of Local Uniformity Measures in Random Graphs and an Application in Finance

Ümit Işlak
umitislak@gmail.com
Boğaziçi University, Istanbul,Turkey

We study local uniformity measures in networks and analyze their moments in Erdős–Rényi graphs. The statistics of interest include degree, clustering, and efficiency indices, as well as certain algebraic constructions. We complement the theoretical results with simulations on alternative random graph models. Lastly, we discuss connections to a financial instability problem and potential applications in classification problems. (Joint work with Büşra Temoçin and Barış Yeşiloğlu.)

Mazes and Underlying Graphs

Kadir Pehlivan

kpehlivan58@gmail.com

Boğaziçi University, Istanbul,Turkey

I will talk about how mazes can be seen as graphs, how to build and solve a maze using graph related algorithms. I will examine how global properties and existance of certain local structures of the underlying graph affects the difficulty of a maze.

Data-Driven Recovery of Network Dynamics and Detecting Critical Transitions

Berke Özgür Arslan
berkeozgur.arslan@stu.khas.edu.tr
Kadir Has University, Istanbul, Turkey

Anticipating critical transitions in complex systems, ranging from brain networks to climate dynamics, depends crucially on our ability to uncover both their internal dynamics and network structure from limited and noisy data. In this talk, I introduce a unified framework for reconstructing governing dynamics and interaction topologies in weakly coupled chaotic networks, leveraging model reduction techniques and recent advances in data-driven system identification. Exploiting stochastic fluctuations as informative fingerprints of the underlying network architecture, the method was shown to enable us to accurately forecast critical transitions even when the system is driven far from its observed states [1]. So far, this was done for networks with discrete dynamics, making use of a rigorous reduction theorem which held for particular systems , although the method was shown empirically to work with a broader family of dynamics under weaker assumptions and was validated on both simulated networks inspired by cortical connectivity and experimental neuronal recordings from mouse neocortex[2]. I will share more recent advancements on extending this paradigm to networks with continuous dynamics, in particular, oscillator networks and discuss how phase reduction techniques may allow us to expand the usability of this paradigm to a much broader set of dynamics.

References

[1] D. Eroglu, M. Tanzi, S. van Strien, T. Pereira, Phys. Rev. X 10, 021047 (2020).
[2] I. Topal, D. Eroglu, Phys. Rev. Lett. 130, 117401 (2023).

Cluster Synchronization and Network Reconstruction on Hypergraphs

Ricardo Tetti Camacho

ricardo.camacho@khas.edu.tr

Kadir Has University, Istanbul, Turkey

Cluster synchronization is a fundamental phenomenon in network dynamical systems, underlying modular coordination and functional transitions in systems such as the brain. Detecting and characterizing these cluster states requires knowledge of the interaction patterns among the nodes. Remarkably, data-driven reconstructions often reveal higher-order interactions that go beyond pairwise coupling. These hyperedges not only emerge from the reconstruction process but can themselves generate cluster synchronization. Understanding this interplay motivates extending the theory of cluster synchronization from pairwise networks to hypergraphs, a step that is essential for detecting critical transitions in brain-like systems, where changes in synchronization patterns reflect shifts between functional states. In this talk, I will discuss how reconstruction reveals hyperedges and how cluster synchronization can be analyzed and utilized within this higher-order networks.

On the Topological Indices of Extended Transformation Graphs

Musa Elsıkma
musa.elsikma@ege.edu.tr
Ege University, Izmir, Turkey

In this study, detailed information will be provided on the calculation methods of various degree-based and distance-based topological indices for extended transformation graphs derived from r-regular graphs. Furthermore, the numerical values of selected topological indices of these derived graphs, obtained under different graph operations, will be systematically tabulated and presented.