Contribution ID: **56** Type: **not specified**

Diffusion Signals Reveal Hidden Connections: A Physics-Inspired Framework for Link Prediction via Personalized PageRank Signals

Thursday, 27 November 2025 17:18 (1 minute)

Link prediction in complex networks–identifying the missing or future connections–remains a cornerstone problem for understanding network evolution and function, yet existing methods struggle to balance computational efficiency with theoretical rigor across heterogeneous topologies. This work introduces a physically principled framework, Diffusion Distance with Personalized PageRank (D-PPR), which unifies static topology with dynamic information flow by modeling nodes as signal sources propagating through the network via Personalized PageRank (PPR) vectors. The method quantifies node-pair similarity through the graph Laplacian-governed diffusion distance between their topology-aware signal distributions, thereby bridging microscopic interactions with macroscopic network dynamics. Systematic benchmarking on synthetic (Barabási-Albert, LFR) and seven large-scale real-world networks spanning technology, biology, and social domains demonstrates that D-PPR achieves highly competitive performance, yielding favorable results when compared to representative local and global heuristics, particularly in sparse and modular networks. These findings establish a rigorous foundation for physics-inspired link prediction by revealing that incorporating dynamical processes into structural similarity metrics enables deeper insights into network connectivity patterns, offering both methodological advances and new theoretical perspectives on the interplay between topology and dynamics.

Primary authors: 邓, 为炳 (华中师范大学物理科学与技术学院); 王, 慧林 (华中师范大学)

Presenter: 王, 慧林 (华中师范大学)

Session Classification: Poster