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Editorial: Network learning and propagation dynamics analysis

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Editorial on the Research Topic
Network learning and propagation dynamics analysis

1 Introduction

In a rapidly expanding digital interconnectivity era, understanding how information, behaviors, and innovations propagate through complex networks has become a central interdisciplinary challenge. From online social platforms to transportation systems, scientific collaboration, and cybersecurity, network-driven diffusion processes are shaping collective decision-making and system performance. The Topic "Network Learning and Propagation Dynamics Analysis" brings together a diverse set of 13 high-quality studies that explore the mechanisms, structures, and emergent patterns of learning and propagation within multi-agent, multi-layered, and heterogeneous networks.

The articles we gathered range in subject from the diffusion of diseases and behavioral modeling of the epidemic, to public opinion governance, recommender systems, edge caching, and other related fields. These studies show that the theoretical richness and practical significance of propagation dynamics in contemporary complicated systems are reflected by the use of tools such as networks theory, data science, physics, and artificial intelligence.

2 Presentation of the papers

The first paper, titled "*Dynamics analysis of epidemic spreading with individual heterogeneous infection thresholds*" (Li) studies the diffusion of epidemics on single-layer complex networks by analyzing the individual vulnerability of each vertex in relation to infection spread and modeling it with a logarithmic threshold. It develops novel theoretical models for epidemic dynamics. This study paves the way for developing vaccination and containment strategies.

The second paper, titled "*The coupled awareness-epidemic dynamics with individualized self-initiated awareness in multiplex networks*" (Zhang et al.), derives a Microscopic Markov Chain Approach (MMCA) and validates its correctness with Monte Carlo simulations to provide a joint model of awareness and epidemic propagation while considering self-induced awareness at an individual level. The probability of an individual becoming aware is conditional on the number of their aware social links. Individuals'

knowledge increase reduces the epidemic's spread, and a metacritical threshold λc appears as a result of the propagation of this knowledge.

The third paper, titled "*Information propagation characteristic by individual hesitant-common trend on weighted network*" (Jia et al.), proposes a network model with cautious and casual users and studies the spread of information. They find that different behaviors have substantial effects on information spread rate and scale. A transition from first-order and second-order phase transitions is found. The evidence of the edge-partition theory by simulations allows us to observe how individual opinions affect aggregate spreading behaviors of heterogeneous networks.

The fourth paper, titled "*The information propagation mechanism of individual heterogeneous adoption behavior under the heterogeneous network*" (Cui et al.), introduces a two-tiered heterogeneous network framework that integrates unique hesitant and standard adoption mechanisms to investigate information dissemination in intricate networks. Simulations demonstrate that when one layer is dominant, it results in second-order continuous phase shifts, whereas balanced layers trigger first-order discontinuous changes. And elements like hesitation parameters and the diversity of node degrees impact the spread significantly.

The fifth paper, titled "*A novel spreading dynamic based on adoption against the trend*" (Hao et al.), introduces a novel formulation of the process of opinion diffusion under the influence of opposing adoption. The simulations on ER and SF networks indicate that polarized oppositions hinder the diffusion process, while moderate opposition allows for a smooth second-order phase transition and leads to rough first-order phase transition. The non-conformist influence over the patterns of propagation in social systems is mutually determined together with bounded influence and susceptibility.

The sixth paper is titled "*Communication dynamics of congestion warning information considering the attitudes of travelers*" (Yan et al.). In this paper, a social network background is incorporated by a congestion alert system that propagates information spreading using dynamical systems and optimal control theory. Results show that sensitivity to reputation and higher propensity to share contributes to more extensive dissemination and, thus, less congestion.

The seventh paper, titled "*Analysis of differences in fossil fuel consumption in the world based on the fractal time series and complex network*" (Zhang et al.), performs a detailed study of the fossil fuel usage of 38 countries using fractal times series analysis and complex network methodologies. The results show that usage is resilient for a long duration of time, in other words demonstrating high Hurst exponents. The visibility graph methodology also exposes the structure of the data, thus underlining the disparities between countries.

The eighth paper, titled "E*ffect of network structure on the accuracy of resilience dimension reduction*" (Liu et al.), explores the fidelity of resilience dimensionality reduction with the impact of the network structure. In these experiments, real-world and synthetic networks are used; it was shown that high assortativity, clustering, and a large modularity cause improved performance. Enhanced fidelity is observed for both social and small-world networks owing to specific topological properties. Theoretical support from this work suggests that refining network topology can improve robustness evaluation, so to enable more effective strategies to examine complicated systems under disruption.

The ninth paper, titled "*Exploring network dynamics in scientific innovation: collaboration, knowledge combination, and innovative performance*" (Jia et al.), constructs a multilayer framework of institutions, knowledge components, and innovative outputs to examine the impact of collaboration and knowledge attributes on innovation effectiveness and network behavior. Results indicate that the variety, distinctiveness, and centrality of knowledge in collaborative networks substantially enhance innovation results.

The tenth paper, titled "*SABTR: semantic analysis-based tourism recommendation*" (Li et al.), introduces a tourist attraction recommendation framework, SABTR, that combines LDA topic modeling with collaborative filtering to recover latent user preferences and predict missing ratings. Results on our modified datasets show that SABTR outperforms conventional models (such as PLSA or Skip-Gram) when data are sparse. This improves both the accuracy and coverage of the echo chamber effect, resulting in a higher selection of diverse and personalized attraction recommendations to the user.

The eleventh paper, titled "*Evolution and governance of online public opinion during COVID-19: a hybrid approach using communication visualization, SIR modeling, and simulation validation*" (Ren et al.), uses a two-stage SIR model along with communication visualization to discuss the dynamics of public opinion during the COVID-19 pandemic. Their findings reveal the importance of key opinion nodes to accelerate the process of the spread of opinion and average nodes to stabilize the situation. Their simulations reveal that optimal government action should be taken at the beginning and the climax of the spread. This study sheds light on the need for personalized guidance and continuous monitoring to maintain stability in online public discussions.

The twelfth paper, titled "*Dynamic analysis of malicious behavior propagation based on feature selection in software network*" (Xue et al.), introduces an efficient recurrent neural network-based malware detection framework, MBDFE, which extracts feature selection based on different feature lengths, specifically n-gram features from API calls sequences, and ranks them based on the information gain. It then classifies their behaviors using RNNs. Their experimental findings illustrate that MBDFE provides a more accurate and faster-to-train solution than the baselines in high-density data cases. MBDFE provides an accurate and scalable solution for the detection and mitigation of malicious activities in software systems.

The last paper, titled "*Epidemic dynamics edge caching strategy for 6G networks*" (Wang et al.), proposes a 6G edge caching technique named CDSED which employs epidemic dynamics to build models of content delivery. The predict genetic-annealing algorithm is adopted in fine-grained optimizing cache allocation to enhance hit probability. Through simulations, we demonstrate that CDSED outperforms LRU, LFU, and MPC schemes in different scenarios, such as when the cache scale, content number, and user numbers are different. The model is able to provide a robust real-time edge content delivery solution for future 6G networks.

Finally, we want to thank all the authors and reviewers who have participated, worked hard in their efforts to organize this challenge, and support our efforts. Our results are both a theoretical and practical contribution toward the comprehension of dynamic complex systems that may find further applications in real and complex intelligently monitored systems.

Author contributions

SN: Writing – original draft. XZ: Writing – review and editing. FX: Writing – review and editing. NZ: Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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