Special Issue: Complex Systems and Intelligent Infrastructures

In an era increasingly defined by uncertainty, interconnectedness and systemic transformation, complexity science has emerged not merely as a theoretical framework, but as an essential lens for making sense of the world. From network dynamics and artificial intelligence to climate tipping points and cultural epistemologies, the field of complex systems continues to expand its relevance and application. This special issue brings together six diverse yet interwoven contributions that collectively explore how intelligent infrastructures and emergent systems are reshaping our understanding of resilience, learning and adaptation in the twenty-first century.

We begin with Reda Benkirane's profound essay, "Complexity in the Twenty-First Century: From the Limits of Growth to the Growth of Limits," which serves as the conceptual cornerstone of this issue. Benkirane challenges us to reconsider not only how we define growth and civilization but also how complexity provides a philosophical and methodological alternative to reductionist paradigms. Drawing on non-Euclidean geometries, planetary boundaries and thinkers such as Leibniz and Ibn Khaldun, the paper reframes the current planetary crisis as a systemic consequence of the way we occupy and fill space and time. It calls for a fusion of science and culture to imagine new forms of agency and learning capable of navigating the limits now confronting our species.

In a compelling example of applied complexity, Smahane Jebraoui, Sidati Khabid and Mohamed Nemiche present an agent-based model of inbound tourism in Morocco, where social influence plays a central role in shaping decision-making. Their network model captures how tourists' preferences evolve through peer interaction and online feedback, revealing leverage points for promoting sustainable tourism and lesser-known destinations. This paper illustrates how social complexity and simulation tools can directly inform policy and planning in socioeconomic contexts.

In the realm of network science and AI, Luyao Wang, Libin Chen, Zhiwei Yang and Kewei Yang propose DRLKHN, a self-learning method based on deep reinforcement learning and graph convolutional networks, to identify key nodes in heterogeneous networks. Their model outperforms traditional centrality-based approaches and adapts to the unique topology of both synthetic and real-world networks. This work adds a powerful tool to the complexity researcher's toolkit, particularly in areas where resilience and influence propagation depend on understanding structural significance.

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From social to infrastructural systems, Fadwa Lachhab and Mohamed Bakhouya introduce a reinforcement learning–based approach for smart lighting and shading control in buildings. By combining Q-learning with IoT technologies and natural language interfaces, their system maintains visual comfort while achieving over 45% energy savings. The work exemplifies how intelligent control systems embedded in physical environments can dynamically adapt to external conditions and user behavior, contributing to greener and more responsive urban infrastructures.

Similarly concerned with infrastructure, Mohammed Amine Jouahri, Zakaria Boulghasoul and Abdelouahed Tajer explore intelligent fault detection in public lighting networks using Mamdani fuzzy inference and scaled conjugate gradient neural networks. Their hybrid approach enables accurate detection of power, lighting and sensor faults in complex urban environments. The fusion of fuzzy logic and neural networks shows how machine intelligence can be harnessed to manage uncertainty and enhance the reliability of smart cities.

Moving to the cyber domain, Abderrahmane Hamdouchi and Ali Idri address the growing threat of cyberattacks in the Internet of Things (IoT) by exploring the use of federated deep learning. Rather than relying on centralized data processing—which poses privacy risks—their study tests 144 federated configurations using DNN and CNN models across real-world datasets. Their results demonstrate that federated learning not only improves privacy but also sustains high accuracy in intrusion detection, offering a robust and scalable path for cybersecurity in distributed systems.

Taken together, the six contributions in this issue span the conceptual, computational and applied dimensions of complex systems. They explore how intelligent infrastructures—whether social, digital or physical—are increasingly shaped by learning processes, feedback loops and the constraints of a world under pressure.

At a time when linear assumptions and siloed disciplines are proving insufficient, these works collectively underscore the need for integrated, adaptive and reflective approaches to complexity. Whether through agent-based models, reinforcement learning, federated AI or philosophical critique, they each illuminate different aspects of how systems learn, evolve and respond under dynamic conditions.

We hope this special issue serves not only as a record of current advances but also as an invitation to future inquiry—one that embraces emergence, anticipates limits and fosters resilience across the many systems that define our shared future.

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