

LECTURE 6

Navigating Through Complexity: From Emergence to Networks

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Abstract

Complex systems are ubiquitous in nature, technology, and society. From ecosystems and the brain to social interactions, transportation infrastructures, and communication systems, collective phenomena often emerge from the interactions of many simple components. Understanding how such emergent behaviors arise remains one of the central challenges of modern science. This introductory lecture will provide a broad overview of the science of complex systems through the lens of complex networks. Starting from examples of collective behavior and emergence in natural and social systems, we will introduce the fundamental concepts of network science and graph theory as a framework for representing and analyzing interacting systems. Basic structural properties, dynamical processes on networks, and simple yet powerful results will be discussed intuitively, requiring minimal mathematical background. The lecture will conclude with examples of applications across diverse disciplines, illustrating how network-based approaches help uncover common principles underlying complex phenomena and provide valuable tools for understanding real-world systems.