2023

Network Science: Core Concepts

NETWORK SCIENCE CORE THEMES

Visualization, **interdependence**, **position**, and **scope** are core themes for using network models to analyze systems. A network 1) is a set of relationships, 2) shows how things are connected, and 3) reveals hidden information.

Visualization

Network models show how people and things are connected by representing them with nodes and edges. A node, also called a vertex, is the smallest part of a network and can represent different things (e.g., a person in a community, a cell in the body). An edge is a line connecting nodes in a network that represents a relationship. Network models can help us visualize any system to understand it better.

Interdependence

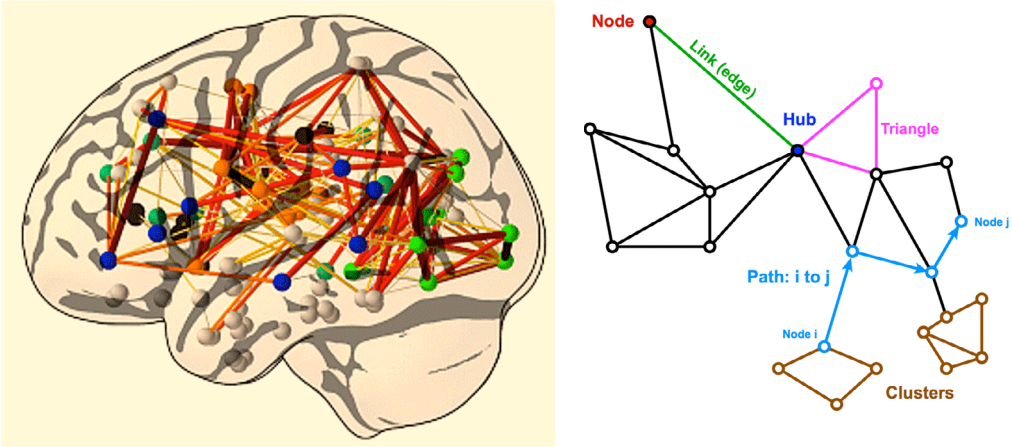
In contrast to a simple cause-and-effect model, a network model highlights the potentially complex interactions among and between nodes. No action or agent connected to a network is truly independent.

Position

The position of nodes in networks determines their relative power, context, and resources.

Scope

Network science offers valuable insights into various systems, ranging from the small-scale to the immense, which exhibit complex (non-linear) outcomes, ripple effects beyond immediate connections (externalities), and shared characteristics across seemingly different situations. Examples include protein interactions, student dynamics in a cafeteria, genetic inheritance, supply chains, ecosystems, the internet, and transportation systems (bus/plane/train routes).



Example system and network model

Guiding Questions

Visualization

- What does the network model represent?
- What do the nodes represent?
- What do the edges represent—what connects or ties the nodes together?

Interdependence

- Does anything flow or move through the system that the network represents?
- Does adding or removing a node influence other nodes in the network?
- Does adding or removing an edge influence other edges in the network?

Position

- Do some nodes have more connections than others?
- Does the network have lots of connections, very few connections, or clusters of connections?
- Does it matter which nodes or which edges are removed or added for flows from node to node?

Scope

- Imagine a small system, like your nervous system; a medium system, like all of the students and teachers in a school; and a large system, like the internet. Messages travel to your brain from other parts of your body just as messages can go through schools and the internet when people are connected. Can you think of other small, medium, or large systems that we can model with networks?

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Brain system and network model source: AD Elster. Network/graph theory: How is network theory used to analyze fMRI data? *Questions and answers in MRI*, https://mriquestions.com/networkgraphs.html