

Title: Network science methods for the analysis, monitor, and control of complex systems

Abstract: It is often the case that *complex systems*, such as critical infrastructures and cyber-physical networked systems, can be represented as static or dynamic *graphs* of many interacting components. These components are typically much simpler in terms of function than the overall system, implying that the additional complexity of the latter is an *emergent network property*.

Network Science is a relatively recent discipline that investigates how the topology and dynamics of such complex graphs affects the behavior, function, and properties of the underlying systems. The high-level objective of Network Science is to provide effective and computationally scalable methods for the analysis, monitor, and control of those systems.

The applications of network science cover physical, technological, informational, biological, cognitive, and social systems.

In this lecture, we will provide an overview of the algorithmic, computational, and statistical methods of network science, as well as various applications.

The participants will:

- Understand what “network science” means, how it relates to other disciplines (graph theory, data mining, machine learning, etc), and how it is useful in practice
- Learn how to detect, quantify and interpret important properties of real networks, such as power-law degree distribution, assortativity, hierarchy, modularity, and others
- Learn how to identify the most important nodes and links in a network through centrality metrics and core identification algorithms
- Design and analyze algorithms that compute “communities” of highly clustered nodes, and learn how to compare such algorithms
- Understand the “network inference” problem and learn statistical and machine learning methods that estimate a network from noisy data
- Learn how to model and predict network epidemics, influence, cascades, and other “spreading” phenomena
- Introduce the problem of network controllability and understand how a network’s structural properties affect the objective to control a system’s dynamic state
- Understand how representation learning (and deep learning in particular) is used in to model and generate complex networks from noisy data