**The Department of
Mechanical Engineering**
PRESENTS

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Winston Chung Hall 205/206
11:10-12:00PM**

Optimal control of networks: energy scaling and open challenges

Abstract:
Recent years have witnessed increased interest from the scientific community regarding the control of complex dynamical networks. Some common types of networks examined throughout the literature are power grids, communication networks, gene regulatory networks, neuronal systems, food webs, and social systems. Optimal control studies strategies to control a system that minimize a cost function, for example the energy that is required by the control action.

We show that by controlling the states of a subset of the nodes of a network, rather than the state of every node, the required energy to control a portion of the network can be reduced substantially. The energy requirements exponentially decay with the number of target nodes, suggesting that large networks can be controlled by a relatively small number of inputs, as long as the target set is appropriately sized.

An important observation is that the minimum energy solution of the control problem for a linear system produces a control trajectory that is nonlocal. However, when the network dynamics is linearized, the linearization is only valid in a local region of the state space and hence the question arises whether optimal control can be used. We provide a solution to this problem by determining the region of state space where the trajectory does remain local and so minimum energy control can still be applied to linearized approximations of nonlinear systems. We apply our results to develop an algorithm that determines a piecewise open-loop control signal for nonlinear systems. Applications include controlling power grid dynamics and the regulatory dynamics of the intracellular circadian clock.

This work is in collaboration with Isaac Klickstein and Afroza Shirin (UNM).

REFERENCES
I. Klickstein, A. Shirin, F. Sorrentino, "Energy Scaling of Targeted Optimal Control of Complex Networks", Nature Communications, 8, 15145 (2017)
I. Klickstein, A. Shirin, F. Sorrentino, "Locally Optimal Control of Complex Networks", Phys. Rev. Lett., 119, 268301 (2017)

About the Speaker:
Francesco Sorrentino received a PhD in Control Engineering from the University of Naples Federico II (Italy). He was first a postdoc and then visiting assistant professor in the Nonlinear Dynamics and Chaos Group at the University of Maryland at College Park. In 2008 he became assistant professor at the University of Napoli Parthenope. In 2012 he joined the Department of Mechanical Engineering at the University of New Mexico. His research primarily focuses on cutting-edge topics in Nonlinear Dynamics and Chaos Theory. His work includes studies on dynamics and control of complex networks, adaptive sensor networks, adaptation in complex systems, and identification of nonlinear systems. Other subjects of interest are the dynamics of large networks of coupled neurons and evolutionary game theory. His research is funded by the National Science Foundation, the Office of Naval Research, and the Defense Threat Reduction Agency.

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