Notre Dame Science
Department of Physics

CONTROLLING FUNCTION IN BIOLOGICAL AND PHYSICAL NETWORKS

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(Refreshments at 3:30 p.m. NSH 202)

Genetic diseases, ecosystem collapses, cascading failures, materials design. These are some of the many outstanding interdisciplinary problems that could benefit from a predictive modeling approach to control the perturbation response of complex systems. The main obstacle to the development of such an approach has been that it is generally unclear how large-scale collective behavior is affected by the local properties of the underlying interaction networks. In this presentation, I will discuss an alternative approach recently developed in my research group, which is based on inverting this perspective and seeking instead the conditions that should be imposed on the local network structure and/or dynamics to generate a desired (natural or human-selected) global collective behavior. In the context of cellular metabolism, this approach has been used to predict that a faulty or sub-optimally operating metabolic network can often be rescued by the targeted removal of enzyme-coding genes. Predictions go as far as to assert that certain gene deletions can restore the growth of otherwise nonviable gene-deficient cells, an effect now known as synthetic rescue. In food-web systems, it leads to the prediction that the removal or growth suppression of specific species can be used to mitigate the spread of extinction cascades. The same approach can be used to rationally design complex systems with new functional properties, such as mechanical networks exhibiting negative compressibility and other forms of mechanical response not found in natural materials. I thus hope to convey that, besides helping explain why "less can be more" in complex systems, these concepts lead to a predictive modeling framework that can be used to control network response.

Colloquium

All interested persons are cordially invited to attend.