Mathematics Colloquium

Balancing Stability and Complexity in Boolean Models of Biological Systems

Sai Bavisetty
UCLA

Friday, October 17, 2025
11:10 am – 12 pm
Building 38, Room 219

Abstract

Boolean networks were first introduced by Kauffman as models for gene regulatory networks. These models have gained popularity because of their simplicity and ability to capture the complex behaviors of biological systems. Currently, the repository Biodivine Boolean Models contains more than 230 Boolean network models.

A systematic investigation of these biological models suggests that they are incredibly robust. In particular, they are resilient to perturbations and tend to reach the same phenotype despite small disturbances. An explanation of this phenomenon was first given by Kauffman, who showed empirically that a network's connectivity determines the stability of the Boolean network. This was further expanded on by Derrida, who provided a theoretical explanation for the effect of connectivity. This was succeeded by many works that looked at various features of biological networks to prove empirically the relation between a network parameter and stability.

Building upon this foundational understanding of robustness in Boolean networks, our work delves into the intrinsic trade-off between phenotypic complexity and network stability. We extend a conjecture proposed by Willadsen, Triesch, and Wiles by proving that entropy (a proxy for phenotypic complexity) provides a tight asymptotic upper bound for coherence (a measure of stability). As a consequence, we derive the Pareto frontier between complexity and stability, allowing us to determine exactly how much stability is achievable for any given level of complexity.

About the speaker: Sai Bavisetty is a Postdoctoral Associate in the Department of Integrative Biology and Physiology at the University of California, Los Angeles. His research interests lie at the intersection of mathematics, biology, and data science, with a focus on gene regulatory networks and topological methods. Prior to his current role, he was a Postdoctoral Associate in the Laboratory for Systems Medicine at the University of Florida. He received his Ph.D. in Mathematics from the University of Illinois Urbana-Champaign.