Emergent dynamics from network connectivity: a minimal model

Carina Curto, Ph.D.
Department of Mathematics
The Pennsylvania State University
University Park, State College

Ecole Polytechnique Federale de Lausanne (EPFL)
Swiss Federal Institute of Technology Lausanne
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Many networks in the brain display internally-generated patterns of activity -- that is, they exhibit emergent dynamics that are shaped by intrinsic properties of the network rather than inherited from an external input. While a common feature of these networks is an abundance of inhibition, the role of network connectivity in pattern generation remains unclear.

In this talk I will introduce Combinatorial Threshold-Linear Networks (CTLNs), which are simple "toy models" of recurrent networks consisting of threshold-linear neurons with binary inhibitory interactions. The dynamics of CTLNs are controlled solely by the structure of an underlyingdirected graph. By varying the graph, we observe a rich variety of emergent patterns including: multistability, neuronal sequences, and complex rhythms. These patterns are reminiscent of population activity in cortex, hippocampus, and central pattern generators for locomotion. I will present some theorems about CTLNs, and explain how they allow us to predict features of the dynamics by examining properties of the underlying graph. Finally, I'll show examples illustrating how these mathematical results guide us to engineer complex networks with prescribed dynamic patterns.