Threshold-linear networks, attractors, and oriented matroids

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Threshold-linear networks (TLNs) are common firing rate models in theoretical neuroscience that are useful for modeling neural activity and computation in the brain. They are simple, recurrently-connected networks with a rich repertoire of nonlinear dynamics including multistability, limit cycles, quasiperiodic attractors, and chaos. Over the past few years, we have developed a mathematical theory relating stable and unstable fixed points of TLNs to combinatorial properties of an underlying graph. The resulting "graph rules" and "gluing rules" provide a direct link between network architecture and key features of the dynamics. Many open questions remain, however, such as: How do changes in network parameters, such as connectivity, transition a TLN from one dynamic regime to another? In this talk, I present some new results in the bifurcation theory of TLNs, with an eye towards understanding how these networks may evolve via training (or learning). It turns out that a certain family of determinants related to the underlying hyperplane arrangement of a TLN is key. In particuar, the theory of oriented matroids and Grassmann-Plucker relations provide valuable insights into the allowed fixed point configurations of TLNs, as well as the allowed bifurcations.