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Topological Principles of Control in Dynamical Networks JASON KIM, Univ of Pennsylvania, FABIO PASQUALETTI, University of California, Riverside, DANIELLE BASSETT, Univ of Pennsylvania — Networked biological systems, such as the brain, feature complex patterns of interactions. To predict and correct the dynamic behavior of such systems, it is imperative to understand how the underlying topological structure affects and limits the function of the system. Here, we use network control theory to extract topological features that favor or prevent network controllability, and to understand the network-wide effect of external stimuli on large-scale brain systems. Specifically, we treat each brain region as a dynamic entity with real-valued state, and model the time evolution of all interconnected regions using linear, time-invariant dynamics. We propose a simplified feed-forward scheme where the effect of upstream regions (drivers) on the connected downstream regions (non-drivers) is characterized in closed-form. Leveraging this characterization of the simplified model, we derive topological features that predict the controllability properties of non-simplified networks. We show analytically and numerically that these predictors are accurate across a large range of parameters. Among other contributions, our analysis shows that heterogeneity in the network weights facilitate controllability, and allows us to implement targeted interventions that profoundly improve controllability. By assuming an underlying dynamical mechanism, we are able to understand the complex topology of networked biological systems in a functionally meaningful way.

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