PREDICTING AND CONTROLLING TIPPING POINTS IN NETWORKED SYSTEMS

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A variety of complex dynamical systems, ranging from ecosystems and the climate to economic, social, and infrastructure systems, can exhibit a tipping point at which an abrupt transition to a catastrophic state occurs. To understand the dynamical properties of the system near a tipping point, to predict the tendency for the system to drift toward it, to issue early warnings, and finally to apply control to reverse or slow down the trend, are outstanding and extremely challenging problems. We consider empirical mutualistic networks of pollinators and plants from the real world and investigate the issues of control, recovery, and early warning indicators. In particular, when considering bipartite networks, both exhibit a tipping point as a parameter characterising the population decay changes continuously, at which the system collapses suddenly to zero abundance for all the species. We articulate two control strategies: (a) maintaining the abundance of a single influential pollinator and (b) eliminating the factors contributing to the decay of the pollinator. In both cases, we find that control can turn the sudden collapse into a more gradual process in the sense that extinction of the species occurs sequentially with variation of the parameter, indicating that control can effectively delay the occurrence of global extinction. We then investigate population revival as the bifurcation parameter varies in the opposite direction away from the tipping point. Without control, there is a hysteresis loop which indicates that, in order to revive the species abundance to the original level, the parameter needs to be further away from the tipping point, i.e., the environment needs to be fitter than before the collapse. However, with control the hysteresis behaviour diminishes, suggesting the positive role of control in facilitating species revival. To develop effective control strategies to prevent the system from drifting towards a tipping point is an unsolved problem at the present, and we hope our work can shed light on the challenging and significant problem of understanding and controlling tipping point dynamics in nonlinear and complex systems. Based on compressive sensing, I will also present an efficient approach to reconstructing complex networks from small amounts of data.

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