Dynamic Regime Criteria for Complex Network Reduction: Fertilization as Study Case

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The structure and dynamics of complex phenomena are often modeled by means of networks. In their study, the possibility of node reduction is commonly sought for. Here we present a strategy for such a reduction in terms of a discrete time attractor landscape analysis in conjunction with dynamical regime criteria. In doing so, we address issues such as robustness, redundancy, degeneracy, plasticity and criticality. As an exemplification, we analyze a signaling network for sea urchin flagellum calcium oscillations that control sperm swimming during fertilization [1, 2, 3, 4]. The recurrence of a critical dynamical regime after node deletions is challenging in evolutionary terms. A comparative study of the spread of initial condition perturbations as network nodes are deleted, by means of a modified version of the Derrida plot [5, 6], identifies expansive (chaotic), contractive (regular) and marginal (critical) relative dynamics. This classification provides information that complements the attractor landscape analysis. Coincidence of the reduced network with an alternative continuous time formulation [7] is encouraging. The reduction method is applicable to general logical networks.

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