MS1-1: The influence of canalization on the robustness of finite dynamical systems

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Gene regulatory networks (GRNs) are a collection of genes and other molecules that govern what is happening within a cell. These networks are surprisingly robust to noise and mutations. GRNs are frequently modeled using finite (i.e., time- and state-discrete) dynamical systems. I present a collection of mathematical and computational tools for the study of robustness of finite dynamical systems. The focus is on networks governed by Boolean k-canalizing functions, a recently introduced class of Boolean functions that contains the well-studied class of nested canalizing functions and that is well-suited to model gene regulation. Two measures, the activity and sensitivity of a function quantify the impact of input changes on the function output. I present a generalization of the latter concept, called c-sensitivity, and provide formulas for the activities and c-sensitivity of general k-canalizing functions as well as canalizing functions with more precisely defined structure. A popular measure for the robustness of a network, the Derrida value, can be expressed as a weighted sum of the c-sensitivities of the governing canalizing functions, and can also be calculated for a stochastic extension of Boolean networks. These findings provide a computationally efficient way to obtain Derrida values of generalized Boolean networks, deterministic or stochastic, that does not require simulation.