Multiobjective process and learning in evolved Random Boolean Networks

J.M. Ruiz, P.Villegas, J.Hidalgo, M.A.Muñoz

Departamento de Electromagnetismo y Física de la
Materia e Instituto Carlos I de Física Teórica y
Computacional. Universidad de Granada, E-18071 Granada,
Spain.

(jmruizfranco@gmail.com, mamunoz@onsager.ugr.es)

Random Boolean Networks (RBN's) constitute a simple paradigm to understand real genetic networks. Depending on the mean connectivity k, these networks exhibit two different phases: a frozen phase, for $k < 2$, and a chaotic phase, with $k > 2$. We develop an genetic algorithm in which a RBN has to learn a complex task, and we see that there is a broad region of values of connectivity in which the system can successfully learn the specified task. The learning process can be understood as a multi-objective optimization problem, in which two features can be optimized: the efficiency in performing the specified task (measured by the Hamming distance), and the robustness of the network (measured by the response to external perturbations). For $k \leq 2$, the genetic algorithm leads to canalized networks, that are highly sensitive to perturbations in the topology, but very accurate in performing the learned task. On the other hand, for $k \geq 2$, we obtain very entangled networks, very noisy, but also robust against topological changes. Therefore, depending of what is convenient, we can move in a broad region of connectivity, where the critical point correspond to a good compromise between accuracy and robustness. Experiments support this idea, as real genetic networks have a mean connectivity between $k = 2$ and $k = 3$.