Abstract:

Inspired by empirical observations on honey bee colonies, we analyze the emergence of task differentiation in a model complex system, characterized by an absence of hierarchical control, yet able to exhibit coordinated behavior and collective function. The analysis considers the steady-state response of a mechanical interaction network to exogenous resonant excitation. It demonstrates how an optimal allocation of excitation sensitivities across the network nodes that results in a maximal response may be constructed either using global information about the network topology or, alternatively, through iterated dynamics of an intuitive learning paradigm that only relies on local information within the network. Importantly, the analysis derives explicit conditions on the topology that guarantee optimal selection using only local dynamics, but also describes circumstances when the system may naturally evolve to a condition of collapse, in which all the excitation sensitivities equal zero, at least over intermediate times. The discussion considers the implications to other network designs, including naturally occurring networks, as well as the effects of noise and nonlinearity.