Formation of the Neural Networks under Multiple Constraints

Yuhan Chen

Department of Physics, Hong Kong Baptist University, Hong Kong

Growing evidence shows that the organization of network architecture of neural systems is subjected to a trade-off between physical cost and functional values of the topology. However, what these functional values are is still not well understood. To answer this question, we explored the impact of multiple constraints systematically. We reconstructed two known neural networks, Macaque cortical connectivity and *C. elegans* neuronal connections, to optimize the different combination of multiple constraints, and qualitatively compared the reconstructed networks to the real networks. Firstly under two obvious but apparently contradictory constraints - low wiring cost and high processing efficiency, it is found the reconstructed networks can reproduce the ubiquitous features of the co-existence of the similar modular and hub structure as the real neural networks. However, the correlation between degrees of nodes in the reconstructed networks and that in the real neural networks is quite low, which implies that degrees of nodes in the real neural networks are still affected by other functional factors. Thus we fixed the degrees of nodes as an additional constraint, and found that much more connections can be recovered in the reconstructed networks from the combination of the three constraints. Notably, nearly 70% of connections in the real Macaque cortical network can be recovered under the three constraints. In both neural networks, we identified the outlier nodes with the connectivity strongly violating the three constraints, which contribute most unrecovered connections. Interestingly, most of these outlier nodes have average degrees, but play important roles in the integration of information processing among different functional regions. This implies that functional integration may be a potentially functional requirement shaping the connectivity of the neural systems.