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colloquium

Complex and Efficient Information Processing in Neural Networks: Examples from Small Worms and Fruit Flies

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摘　要：
Neural networks are characterized by their ability of processing large amount of input in parallel. Typical analyses of the network architecture focus on the general network properties including cluster coefficient (local communication) and shortest path length (long-range signal propagation). While much has been learned about the architectures of neural networks by the conventional approaches, two distinct and functionally important properties of neural networks are often overlooked: 1) neural networks are characterized by polarity: signals enter the network from a specific set of input neurons, processed by local neurons and leave the network from output neurons. 2) The neural pathways via multiple synaptic connections may be more important, in terms of high level functionality, than the direct or the shortest synaptic pathways. To address the issue, we developed a novel method of network architecture analysis by considering the information propagation alone the direction of the polarity (vertical propagation) and across the direction (horizontal propagation) with a focuses on propagation through multiple neurons and recurrent pathways. We analyzed neural networks of *Caenorhabditis elegans* (a type of small worms) and *Drosophila* (fruit flies) central complex, and, as comparison, artificially generated small-world networks. We found that the two neural networks perform very well in both propagation directions while classic small-world networks with various rewiring probability exhibit tradeoff between the propagation efficiency in the two directions: They have either good vertical or vertical propagation, but not both. Further analyses showed that, comparing to the artificial networks, the information processing in the two neural networks are characterized by higher number of pathways, indicating higher processing complexity. Interestingly, we found that in the Drosophila central complex the complexity is highly dependent on a pair of neurons and they seem to play critical roles in mapping sensory information between brain regions.