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Sparsity and compressed coding in neuronal networks

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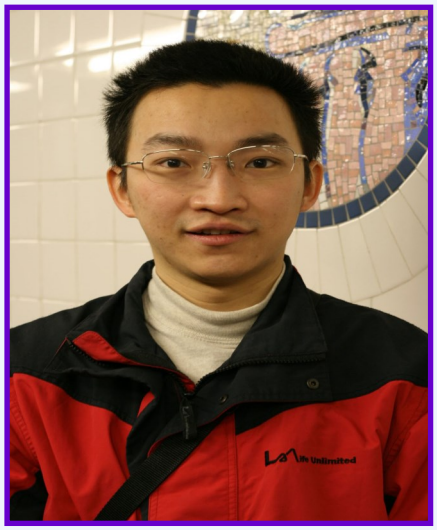

Considering that many natural stimuli are sparse, can a sensory system evolve to take advantage of this sparsity? We explore this question and show that significant downstream reductions in the numbers of neurons transmitting stimuli observed in early sensory pathways might be a consequence of this sparsity. First, we model an early sensory pathway using an idealized neuronal network comprised of receptors and downstream sensory neurons. Then, by revealing a linear structure intrinsic to neuronal network dynamics, our work points to a potential mechanism for transmitting sparse stimuli, related to compressed sensing (CS) type data acquisition. Through simulation, we examine the characteristics of networks that are optimal in sparsity encoding, and the impact of localized receptive fields beyond conventional CS theory. The results of this work suggest a new network framework of signal sparsity, freeing the notion from any dependence on specific component space representations. We expect our CS network mechanism to provide guidance for studying sparse stimulus transmission along realistic sensory pathways as well as engineering network designs that utilize sparsity encoding.

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