Poster presentation

Neural mechanism for temporal integration of the fluctuating component of an external input

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Temporal integration of information plays a crucial role in a variety of cognitive processes, such as sensory discrimination, decision-making or interval timing. However, neural mechanisms of this computation remain to be elucidated. In previous models of temporal integration by recurrent neuronal networks [1] or by single cells [2], neurons integrate a constant external input. Recent lines of evidence, however, suggest that activity of in vivo cortical neurons is driven by noisy, balanced excitation and inhibition [3,4]. Here we propose a recurrent neural-network model that integrates a noisy external input. We show that the temporal integration in this network is more accurate when it integrates the fluctuating component of this input rather than the mean value.

We consider a uniform recurrent network of N excitatory leaky integrate-and-fire neurons. All the neurons are initially in the resting state ('off' state); if a neuron discharges a spike, it moves to another state ('on' state) where constant depolarizing current is active, which promotes regenerative spike discharges. Each neuron receives an external input that consists of excitatory and inhibitory bombardments, which generates a rapidly varying postsynaptic current $I(t) = \mu + \sigma\xi(t)$. Here μ and σ^2 are the mean and the variance of this current, respectively; ξ denotes fluctuation with zero mean, which is approximated by Gaussian white noise.

It is analytically or numerically shown that, if the strength of recurrent connection is properly tuned, the number of neurons in the 'on' state, say n, grows with time at an exact-constant rate. When σ^2 is varied while μ is constant, the constant growth is kept, with its rate scaling linearly with σ^2. In contrast, the constant growth is not kept when μ is varied while σ^2 is constant. These results indicate that n represents temporal integration of the variance but not the mean of an external input. We further propose that n is decoded by the firing rate of a downstream neuron that has afferent inputs from the recurrent network, which are mediated by NMDA current.

References
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