Abstract View

FIRING RELIABLY WITH UNRELIABLE SYNAPSES.

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Recent recordings from neurons in the cat LGN and striate cortex in vivo have shown that repeated presentations of the same time-varying visual input yield reliable and precise firing. This finding is surprising because 1) cells in vivo are constantly receiving background synaptic inputs, 2) synaptic release is stochastic 3) synapses have complex short-term dynamics that interfere with postsynaptic signal integration. Consequently, when an identical set of incoming spike trains is repeatedly presented at pre-synaptic terminals, the post-synaptic neuron will undergo a somewhat different pattern of current at its soma, from trial to trial. How, then, does the post-synaptic neuron generate the same reliable response, when the synaptic current arriving at the soma varies significantly?
We used a realistic multi-compartmental biophysical model of a reconstructed cat stellate cell with thousands of excitatory and inhibitory dynamical synapses to investigate three hypotheses for achieving reliable output firing patterns. 1) The pre-synaptic spikes from LGN neurons are temporally correlated. 2) The pre-synaptic spikes contain bursts of action potentials. 3) Subsets of synapses are spatially organized onto specific dendritic regions of the cell.
We found that reliable firing patterns could be obtained for a surprisingly low level of pre-synaptic temporal correlation, that specific pre-synaptic intra-burst frequencies and burst lengths were optimal for reliable post-synaptic firing, and that spatial grouping was in general detrimental to reliable firing. These results place morphological and physiological constraints on the LGN to V1 information flow and highlight interactions between the spatial distribution and timing of excitatory and inhibitory inputs. We discuss these results in the context of simple cells' orientation selectivity and receptive field formation.
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