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Poster presentation

Multicompartment leaky integrate and fire neuron modeling with multiexponentials

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Introduction

Dendritic processing is paramount in the mammalian olfactory bulb where mitral cells modulate each other via granule cell interneurons that synapse on the mitral cells' lateral dendrites. This motivated us to construct computationally lean multicompartment leaky integrate and fire (LIF) neurons such that each compartment's membrane potential is described by six exponentials. This enables the model to avoid differential equations and calculate the membrane potential only upon receiving synaptic events and, like the LIF point neuron, employs simple rules for propagating and attenuating dendritic action potentials.

Methods and results

We first demonstrate the application of a multiexponential fitting algorithm [1] by casting the passive infinite cable response to a delta function at various normalized distances as a sum of six exponential functions. Because the multi-exponential fit is so accurate (see Figure 1 for normalized distances of $X = 1$ and $X = 3$), we, in turn, account for branching, tapering, and reflections in finite cables by employing a variant of the method proposed by Abbott [2], using our six exponentials as our "Green's function". Multicompartment cells built with these exponentials then process new events simply by updating the magnitudes of a compartment's six exponential functions.

We contrast our reconstruction of the Bhalla-Bower mitral cell [3] as a multicompartment LIF with the biophysical model monitored at various dendritic locations with different inputs using the NEURON simulation environment [4]. We also compare the processing time and network activity of mitral-granule circuits constructed to quantify the spatial extent and conditions of synchrony between sets of glomeruli in the olfactory bulb with networks comprised of biophysical cells vs. our multicompartmental LIF cells.

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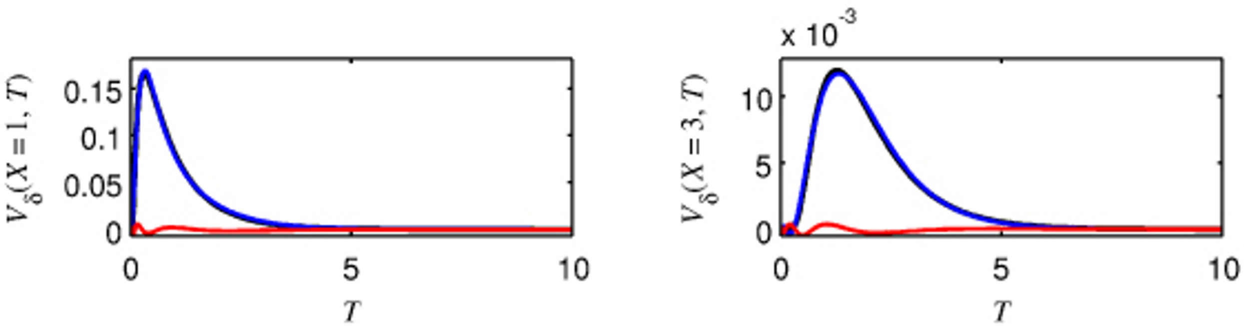

Figure 1

Passive membrane response to a delta function on an infinite cable (black) compared with the fit to six exponentials (blue) at normalized locations *X* = 1 (left) and *X* = 3 (right) across time (*T* = *t*/τ). Red line is the error between the functions. Note that the vertical scales are different between the left and right figures.