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Entrainment of a thalamocortical neuron to periodic sensorimotor signals

Dennis Guang Yang*, Yixin Guo

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In this work we study the dynamics of a 3-dimensional conductance-based model of a single thalamocortical (TC) neuron in response to sensorimotor signals. In particular, we focus on the entrainment of the system to a periodic excitatory signal that alternates between 'on' and 'off' states lasting for time T_1 and T_2, respectively. By exploiting invariant sets of the system and their associated invariant fiber bundles that foliate the phase space, we reduce the dynamics to the composition of two 2-dimensional maps, with the two components of one of the maps being simply a uniform shift and a uniform decay. With this reduction in computational complexity, we are able to analyze the model's response to the excitatory signal while varying T_1 and T_2 systematically. We find that for fixed T_2 but different T_1 there exist and in some cases co-exist entrained periodic oscillations with different number of spikes (see Figure 1 for the case with T_2 = 60 milliseconds). For relatively large T_2 (above 55 milliseconds) it is also possible that the model responds to the excitatory signal with delayed

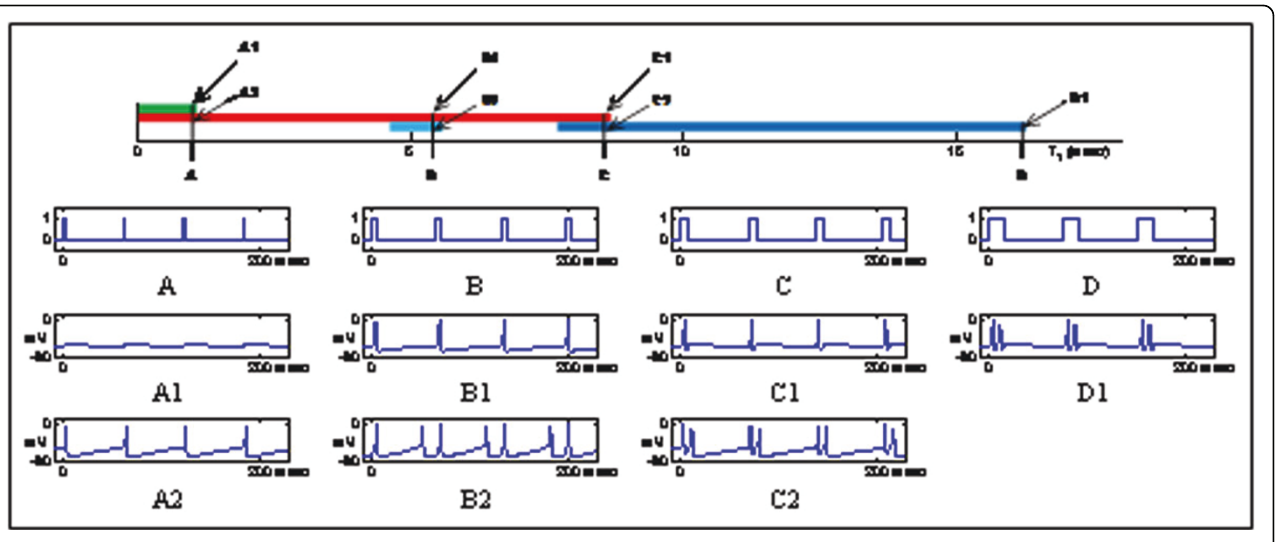

Figure 1 The top panel shows the T_1 intervals (with T_2 = 60 milliseconds) for the existence of different families of entrained periodic oscillations (green for sub-threshold oscillations, red for 1-spike oscillations, dark blue for 2-spike oscillations, and light blue for 2-spike oscillations with a delayed second spike.) Panels A, B, C, and D illustrate the periodic excitatory signals with T_2 = 60 milliseconds and T_1 = 1.014, 5.399, 8.545, and 16.15 milliseconds, respectively. Panels A1, A2, B1, B2, C1, C2, and D1 show the time series plots of the different types of periodic oscillations entrained to the excitatory signals with T_1 values indicated in the top panel.

* Correspondence: yixin@math.drexel.edu
Departmentof Mathematics, Drexel University, Philadelphia, PA 19104, USA
Full list of author information is available at the end of the article

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spikes. Furthermore, we find that the size of the T_1 intervals that allow coexistence of different types of entrained oscillations becomes larger as T_2 increases.

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