Dynamical mechanisms of Type III responses in a nonlinear hybrid neuron model

Justyna Signerska-Rynkowska
Gdańsk University of Technology
justyna.signerska@pg.edu.pl

Jonathan Rubin
Department of Mathematics, University of Pittsburgh
jonrubin@pitt.edu

Jonathan Touboul
Department of Mathematics and Volen National Center for Complex Systems, Brandeis University
jtouboul@brandeis.edu

The dynamic mechanisms shaping neurons’ responses to transient inputs can bear significant physiological relevance and is connected, among others, with such phenomena as post-inhibitory facilitation (PIF), where an otherwise subthreshold excitatory input can induce a spike if it is applied with proper timing after an inhibitory pulse, and slope detection, in which a neuron spikes to a transient input only when the input’s rate of change is in a specific, bounded range. These phenomena have been previously associated with so-called Type III neurons (in Hodgkin’s classification) which are those neurons that never exhibit continuous firing in response to sustained excitatory currents.

In our study we analyse responses to transient inputs in nonlinear adaptive hybrid models and provide a geometric characterization of dynamical structures associated with PIF and an analytical study of slope detection for tent inputs. In particular, our proofs show that PIF and slope-detection do not always require pure Type III regime.