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A dynamical system analysis of the adaptive spike threshold

Jonathan Platkiewicz* and Romain Brette

Address: Odyssee (INRIA/ENS/ENPC), Département d'Informatique, Ecole Normale Supérieure, 45, rue d'Ulm, 75230 Paris Cedex 05, France

Email: Jonathan Platkiewicz* - platkiew@di.ens.fr

* Corresponding author

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Recent *in vivo* experiments have revealed that the action potential threshold depends on the rate of depolarization just preceding the spike. This phenomenon can be reproduced in the Hodgkin-Huxley model. We analyzed spike initiation in the (V, h) phase space, where h is the sodium inactivation variable, and found that the dynamical system exhibits a saddle equilibrium, whose stable manifold is the curve of the threshold. We derived an equation of this manifold, which relates the threshold to the sodium inactivation variable. It leads to a differential equation of the threshold depending on the membrane potential, which translates into an integrate-and-fire model with an adaptive threshold. The model accounts well for the variability of threshold and the slope-threshold relationship. See figure 1.

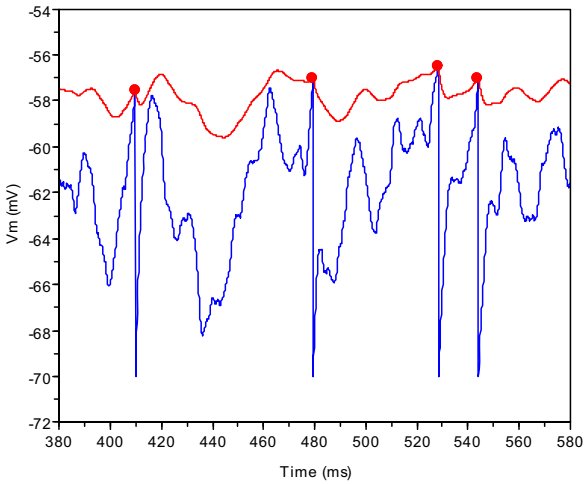

Figure 1
Sample trace of a noise-driven integrate-and-fire model with adaptive threshold. Blue: membrane potential, red: spike threshold.

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