IEICE Proceeding Series

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Vol. 1 pp. 363-363
Publication Date: 2014/03/17
Online ISSN: 2188-5079

2012 International Symposium on Nonlinear Theory and its Applications
NOLTA2012, Palma, Majorca, Spain, October 22-26, 2012

The interplay of subthreshold currents, spiking activity and noise in a model of a cold receptor

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We study the Huber-Braun neuron model originally designed to mimic the dynamics of mammalian cold receptors. This model combines subthreshold currents and a Hodgkin-Huxley spiking mechanism and is thus capable of generating various different spiking patterns depending on a control parameter. Since a total diminution of subthreshold activity corresponds to a decomposition of the model into a slow, subthreshold, and a fast, spiking subsystem, we first elucidate their respective dynamics separately and draw conclusions about their role for the generation of different spiking patterns. These results motivate a numerical bifurcation analysis of the effect of varying the strength of subthreshold currents, which is done by varying a suitable control parameter. We work out the key mechanisms which can be attributed to subthreshold activity and furthermore elucidate the dynamical backbone of different activity patterns generated by this model. Particularly we are interested in a homoclinic bifurcation, which is related to the transition from tonic firing to bursting behavior. We show that this bifurcation is not only of interest for the deterministic dynamics but also for the noisy dynamics of the neuron. It marks a division line in parameter space beyond which the response of the neuron to current and conductance noise is very different. Current noise corresponds to a noise source in the dynamic equation for the membrane potential while conductance noise mimics the stochasticity of ion channels.