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Analysis of dynamics of a map-based neuron model via Lorenz maps

Frank Llovera[1]

[1] *Gdańsk University of Technology, Department of Applied Mathematics*

Modeling nerve cells can facilitate formulating hypotheses about their real behavior and improve understanding their functioning. We study a discrete neuron model introduced by Courbage, Nekorkin and Vdovin in 2007, where the originally piecewise linear function defining voltage dynamics is replaced by a cubic polynomial, with an additional parameter responsible for varying the slope. Showing that on a large subset of the multidimensional parameter space the return map of the voltage dynamics is an expanding Lorenz map, we analyze both chaotic and periodic behaviour of the system and describe complexity of spiking patterns fired by a neuron. This is achieved by using and extending some results from the theory of Lorenz-like and expanding Lorenz mappings.