A new insight into the dynamics of the Chialvo model

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In the last decades, various discrete models of a single neuron appeared. One of the prominent examples is the model introduced by Chialvo in 1995 ([1]).

Firstly, I will show that its reduced one-dimensional version can be treated as an independent simple model of neural activity where the input and the fixed value of the recovery variable are parameters. This one-dimensional model still displays very rich and varied dynamics. Using the fact that the map whose iterates define voltage evolution is S-unimodal, both its periodic behavior and the occurrence of different notions of chaos can be described in detail and corresponding regions in parameter space are indicated.

However analytical methods offer limited insight into the nature of some phenomena encountered by the original two-dimensional multi-parameter version of this model. Therefore in the second part of the talk I will present the results of its computer-assisted analysis. For that purpose, we apply the method for rigorous analysis of global dynamics based on a set-oriented topological approach, introduced by Arai et al. in 2009 ([2]). We enrich the existing tools with a new approach that we call Finite Resolution Recurrence. The method analyzes the return times inside chain recurrent sets and, together with the information on the size of the chain recurrent set, allows one to determine subsets of parameters for which chaotic dynamics may appear. We obtain a comprehensive picture of global dynamics of the model, and we reveal its bifurcation structure. This approach can be applied to a variety of dynamical systems.

The talk is based on co-authored works [3] and [4].

References

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