Topic for a

Master thesis / Diplomarbeit

Dendritic Computing in Spike Chains

At the Chair of Fundamentals of Electrical Engineering novel neuronal circuits are investigated to enable non-conventional and low-power analog computing systems [1]. In recent research locally active neuron circuits, like the 2T1RC [2] circuit, are investigated as central building block for chaotic and spike based neural networks. Moreover, information processing in the dendritic parts of neurons became more important for neural computation [3]. This work aims to demonstrate the emulation of spike-based computing for sequence detection tasks.
Within the scope of a scientific work, locally active neuron circuits are investigated by simulation and a hardware realization is built up. The circuit architecture is analyzed and evaluated with a regard to its applicability as complex integrated dendritic computing circuits.

The student thesis should include, but not be limited to, the following:

- Literature search on locally active neuron circuits and dendritic computing concepts
- Design, simulation and physical implementation of a spike chain using 2T1RC circuits
- Training and demonstration of simple sequence detection computing tasks
- Applicability assessment for complex integrated dendritic computing circuits
- Documentation of the results

For this thesis a good knowledge in analog circuit design and simulation (e.g. SPICE or Python) as well as the basics of electrical engineering is required. In-depth knowledge of locally active neuron circuits and dendritic computing principles can be acquired in the course of the student thesis work.

References:
[1] R. Tetzlaff. *Memristors and Memristive Systems*. Springer, 2014
[2] A. S. Demirkol, M. E. Sahin, B. Karakaya, H. Ulutas, A. Ascoli, R. Tetzlaff, „Real time hybrid medical image encryption algorithm combining memristor-based chaos with DNA coding“, Chaos, Solitons & Fractals, Bd. 183, S. 114923, 2024
[3] J. Leugering, P. Nieters, G. Pipa, „Dendritic plateau potentials can process spike sequences across multiple time-scales“, Front. Cognit., Bd. 2, S. 1044216, 2023

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