Topic for a

Master thesis / Diplomarbeit

Simulation of harmonic oscillatory recurrent neural networks

At the Chair of Fundamentals of Electrical Engineering emerging memristive memory devices are investigated to enable non-conventional and low-power analog computing systems [1]. In parallel recent research on harmonic oscillatory recurrent neural networks (HORN) show a tremendous training speed compared to conventional recurrent neural network such as vanilla RNN and LSTM [2]. Moreover, memristive devices are potential candidates to emulate the activation function in HORN in hardware, as well as the oscillation itself using locally active devices. In this context, an open research topic is how the memristive devices can represent the training parameters in HORN or even replace the intrinsic oscillations in the HORN system.
Within the scope of a scientific work, a Python-based simulation framework of HORN is implemented and compared to conventional recurrent neural networks. In a second phase, the HORN is extended with common memristor models envisaging a hardware realization.

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

- Literature research on harmonic oscillatory recurrent neural networks (HORN)
- Implementation of HORN in a Python-based simulation framework
- Comparison to conventional networks, such as RNN and LSTM by training them on a time series data set.
- Implementation of memristor models as training parameters and/or nonlinear oscillator of the HORN
- Documentation of the results

For this thesis a good knowledge on the training of neural networks in a Python framework as well as the basics of electrical engineering is required. In-depth knowledge of memristor modeling can be acquired in the course of the student thesis work.

References:

[1] Tetzlaff, Ronald. *Memristors and Memristive Systems*. Springer, 2014
[2] Effenberger, F., Carvalho, P., Dubinin, I., Singer, W., (2024). The functional role of oscillatory dynamics in neocortical circuits: a computational perspective.

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