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Characterizing Neuromorphic Nanowire Networks via a Unified Computational Framework

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Neuromorphic systems are entities that have abilities that mimic the way the human brain works, one of the most complex systems that we know of. Randomly self-assembled nanowire networks (NWNs) are dynamical systems which have demonstrated brain-like abilities such as remembering stimulus and performing in-situ computations. While there are many models for NWNs, ones which have memristive junctions between nanowires have shown great potential for neuromorphic applications. These memristive junctions are similar to resistive junctions but have memory capabilities and an adaptive resistance that changes with response to inputs, giving them similarity to neurosynapses. The junctions are formed at the nanoscale in which ionic drift-diffusion effects, as well as quantum effects, can be modelled using effective dynamical differential equations describing the conductance evolution and charge mobility within the inner-wire touching points. Since various models have been proposed to capture the largely complex and abstract nature of memristive junctions, we developed a novel computational framework to simulate and analyze NWNs in a more unified manner. Implemented in the Python programming language, our framework allows for the static and dynamic analysis of NWNs under arbitrary memristive models. This framework acts as a foundation for more complex scenarios, such as reservoir computing, information processing, or data classification. Furthermore, we are able to perform large-scale analysis by simulating thousands of NWNs to extract data from. This gives our analysis a unique edge as we can now not only perform these simulations coherently and systematically but also perform them in large batches for better statistical analysis, more accurate predictions, and improved understanding of ensemble behaviours. Effectively, this framework allows for the creation, simulation, and analysis of memristive-based NWNs so that the network simulation pipeline need not be recreated for each new dynamical junction model. It will offer, and play a key role in, exploration and testing of advanced NWN scenarios for neuromorphic computing applications.

Keyword-1

neuromorphic materials

Keyword-2

memristors

Keyword-3

nanowires

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