Finding a path to Computational Advantage of Neuromorphic Computing for Science

Johan H. Mentink
Radboud University, Institute for Molecules and Materials, Nijmegen, The Netherlands

Solving the major challenges in computational science rapidly increases the demand for high-end digital computing infrastructures, leading to unsustainable growth of the corresponding energy costs. Neuromorphic Computing is an emerging computing paradigm that co-locates memory and processing and thereby enables faster and much more energy-efficient computations. Therefore, neuromorphic computing might enable a more sustainable future of scientific computing.

However, understanding how to identify potential advantages of neuromorphic hardware is a nontrivial task and may depend strongly on the computational problem at hand. In this presentation, we will present our recent efforts aimed at identifying computational advantage for quantum simulation of magnetic systems with artificial neural network networks [1,2]. This computational task features two widely used computational problems: (i) the inference of feed-forward neural networks and (ii) Markov-chain Monte Carlo simulation. We explore the potential advantage of these tasks on two established neuromorphic paradigms: in-memory computing [3] and stochastic Ising machines [4].

Taking the energy cost and latency as key performance metrics, we predict that computational advantage appears for sufficiently large systems, which is intimately related to the massive parallelization that is present in the neuromorphic hardware. We also find that computational advantage depends strongly on the properties of the network being realized in physical hardware. Hence, no universal computational advantage exists, and we present a methodology to quantify the possible advantage of neuromorphic Monte Carlo sampling directly from simulations on digital hardware.

We expect that our findings will stimulate further exploration of neuromorphic hardware for computational science, which ultimately will lead to the breaking of existing computational barriers. Moreover, given the generality of the computational tasks, our findings may also stimulate adoption of neuromorphic hardware for non-scientific applications.

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