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Accelerating Neuronal Network Construction through Dynamic GPU Memory Instantiation

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Efficient simulation of large-scale spiking neuronal networks is important for neuroscientific research, and both the simulation speed and the time it takes to instantiate the network in computer memory are key factors. In recent years, hardware acceleration through highly parallel GPUs has become increasingly popular. Similarly, code generation approaches have been utilized to optimize software performance, albeit at the cost of repeated code regeneration and recompilation after modifications to the network model [1].
To address the need for greater flexibility in iterative model changes, we propose a new method for creating network connections dynamically and directly in GPU memory. This method uses a set of commonly used high-level connection rules [2], enabling interactive network construction.
We validate the simulation performance with both consumer and data center GPUs on a cortical microcircuit of about 77,000 leaky-integrate-and-fire neuron models and 300 million synapses [3], and a two-population recurrently connected network designed to allow benchmarking of a variety of connection rules.
We implement our proposed method in NEST GPU [4,5] and demonstrate the same or shorter network construction and simulation times compared to other state-of-the-art simulation technologies. Moreover, our approach meets the flexibility demands of explorative network modeling by enabling direct and dynamic changes to the network in GPU memory.

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The authors BG, GT, and JV have equal contribution.

References

[1] Knight, J.C.; Nowotny, T. GPUs Outperform Current HPC and Neuromorphic Solutions in Terms of Speed and Energy When Simulating a Highly-Connected Cortical Model. Frontiers in Neuroscience 2018, 12. https://doi.org/10.3389/fnins.2018.00941.

[2] Senk, J.; Kriener, B.; Djurfeldt, M.; Voges, N.; Jiang, H.J.; Schüttler, L.; Gramelsberger, G.; Diesmann, M.; Plesser, H.E.; van Albada, S.J. Connectivity concepts in neuronal network modeling. PLOS Computational Biology 2022, 18, e1010086. https://doi.org/10.1371/journal.pcbi.1010086.

[3] Potjans, T.C.; Diesmann, M. The Cell-Type Specific Cortical Microcircuit: Relating Structure and Activity in a Full-Scale Spiking Network Model. Cerebral Cortex 2014, 24, 785–806. https://doi.org/10.1093/cercor/bhs358.

[4] Golosio, B.; Tiddia, G.; De Luca, C.; Pastorelli, E.; Simula, F.; Paolucci, P.S. Fast Simulations of Highly-Connected Spiking Cortical Models Using GPUs. Frontiers in Computational Neuroscience 2021, 15. https://doi.org/10.3389/fncom.2021.62

[5] Tiddia, G.; Golosio, B.; Albers, J.; Senk, J.; Simula, F.; Pronold, J.; Fanti, V.; Pastorelli, E.; Paolucci, P.S.; van Albada, S.J. Fast Simulation of a Multi-Area Spiking Network Model of Macaque Cortex on an MPI-GPU Cluster. Frontiers in Neuroinformatics 2022, 16. https://doi.org/10.3389/fninf.2022.883333.

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