Contribution ID: **20** Type: **Poster**

Fast large-scale spiking neuronal network simulations with NEST GPU: memory and communications optimization

Tuesday 10 September 2024 17:30 (45 minutes)

Efficiently simulating large-scale spiking neuronal networks is crucial for advancing neuroscientific research, where both high simulation speed and minimal memory consumption during network instantiation are essential. NEST GPU [1,2], a high-performance GPU-MPI library developed within the NEST Initiative [3], showcases remarkable simulation speeds for various network sizes, leveraging the computing power of GPU-based systems to accelerate research endeavours. To maximise the utilisation of existing and future computational resources of multi-GPU systems, it is of paramount importance to take into account the implementation of software structures that manage remote connections (i.e., connections between neurons located on different GPUs) and facilitate the efficient communication of spikes across these GPUs. Recent advancements in NEST GPU have been primarily concentrated on following this approach, enhancing its performance and scalability within multi-GPU environments.
Building upon previous work of dynamically constructing networks directly in GPU memory [4], the approach has been expanded to multiple GPUs operating in parallel. This has resulted in significant performance gains. To ensure accuracy, a validation pipeline is being established that automatically compares the spiking activity of neuroscientifically relevant models, such as the cortical microcircuit [5] and the multi-area model of macaque vision-related cortex [6], against their CPU counterparts as a reference. Additionally, an update is provided on the ongoing efforts to align the GPU and CPU components of NEST.

Acknowledgments:
European Union's Horizon 2020 Framework Programme for Research and Innovation under Specific Grant Agreement No. 945539 (Human Brain Project SGA3).
Initiative and Networking Fund of the Helmholtz Association in the framework of the Helmholtz Metadata Collaboration project call (ZT-I-PF-3-026).
Joint Lab "Supercomputing and Modeling for the Human Brain".
Italian PNRR MUR project PE0000013-FAIR CUP I53C22001400006, funded by NextGenerationEU.
We are grateful for the use of Fenix Infrastructure resources, which are partially funded from the European Union's Horizon 2020 research and innovation programme through the ICEI project under the Grant Agreement No. 800858. The authors further thank the INFN APE Parallel/Distributed Computing laboratory and the IAS-6.

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Session Classification: Poster Session