RTG-NCA

Evaluating parameter tuning and real-time **closed loop simulation** of **large scale spiking networks** before mapping to neuromorphic hardware: **Comparing GeNN and NEST**

Felix J. Schmitt, 01.04.2022, NICE 2022

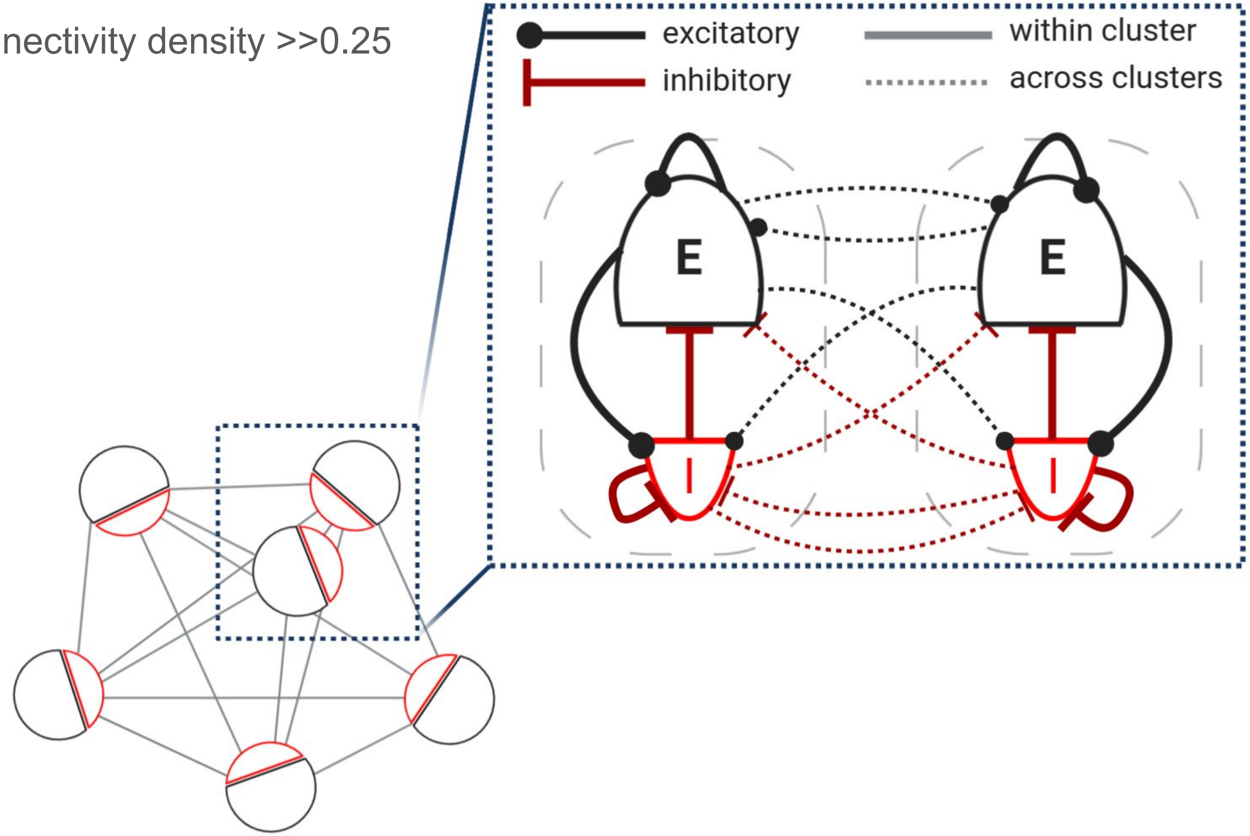
Motivation

Big challenges for computational neuroscience labs:

- Prototyping
- Parameter calibration
- Closed-loop simulations
- Large networks 10k - 10 mio. neurons

Benchmark: Spiking cortical attractor model

- Challenging model
  - Dense network connectivity density >>0.25
  - Metastable activity



[Rostami et al. 2020]
[Litwin-Kumar & Doiron 2012]

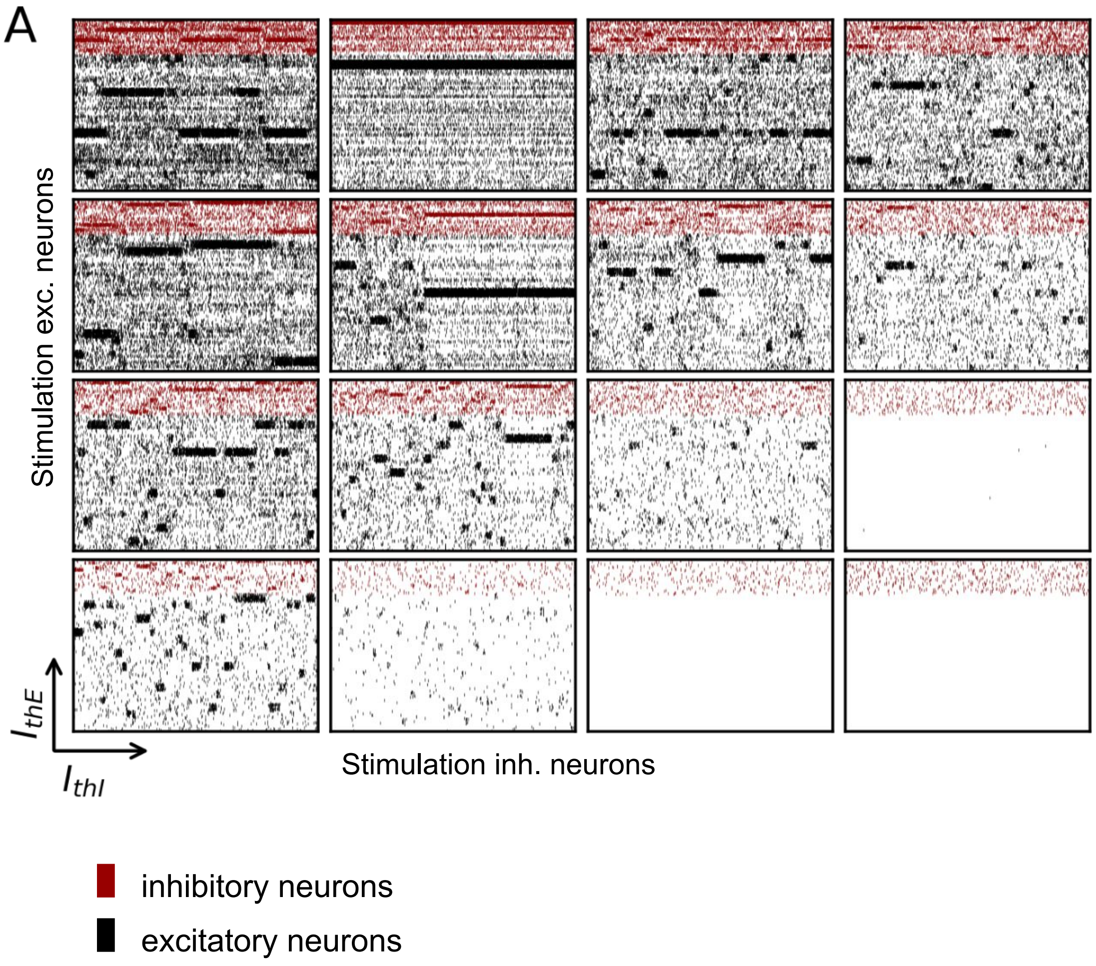
Parameter space

- Parameter space of spiking neural networks are large

Parameter	
N_E	g
N_I	J_E
E_L	J_{EI}
V_{th}	J_{IE}
V_r	J_{II}
C	I_{thE}
τ_m^E	I_{thI}
τ_m^I	I_{stim}
τ_{syn}^E	N_Q
τ_{syn}^I	J_{E+}
τ_r	R_J
p_{EE}	p_{EI}
p_{IE}	p_{II}

Parameter space

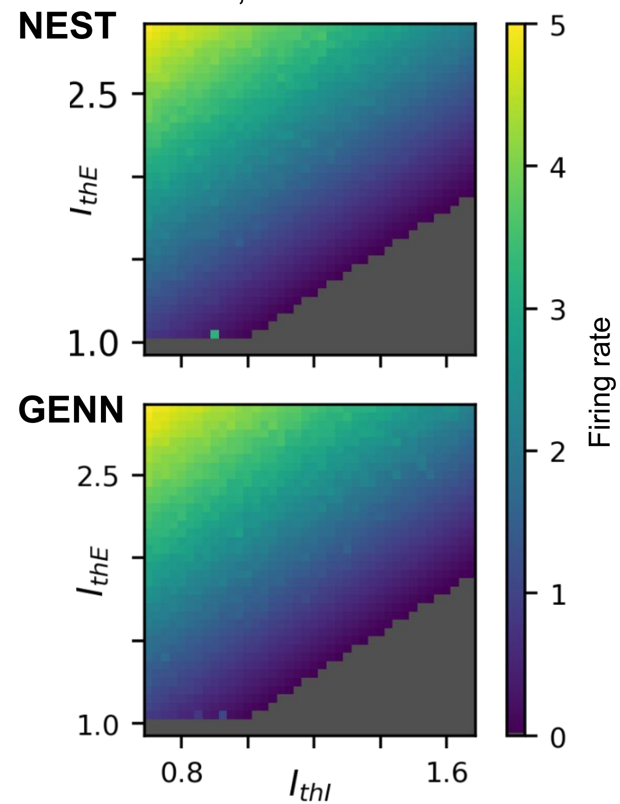
- Parameter space of spiking neural networks are typically very large
- Even simple networks can have very different regimes of operation



Parameter space

- NEST (CPU-based):
  - **12h 45m**
- GeNN (GPU-based):
  - **State-of-the-art GPU** (A6000): **1h 15m**
    Speedup: 10 times
  - **Low budget GPU** (GTX 970): **3h 40m**
    Speedup: 3.5 times

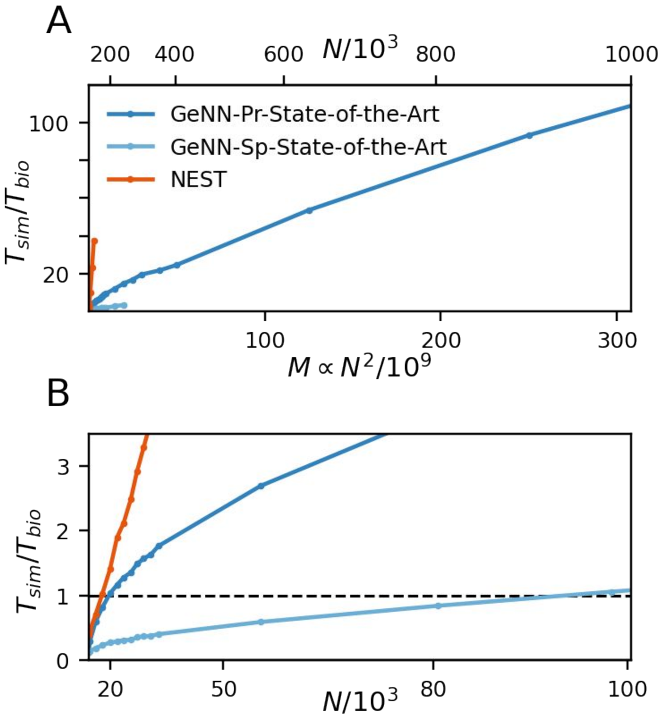
40x40 grid, 10 s per sample,
16,000 s in total



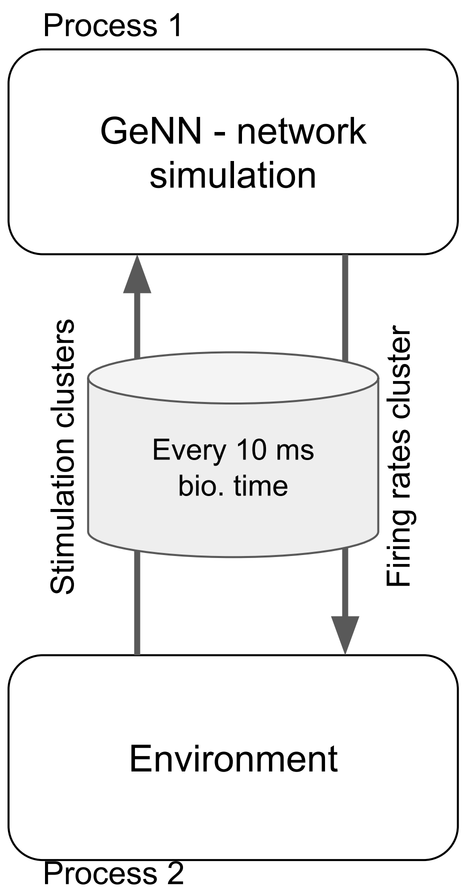
[Gewaltig et al. 2007], [Yavuz et al. 2016], [Knight et al. 2021]

Simulation time vs. network size

- Real-time factor scales ~linearly with number of synapses
- NEST can simulate up to 15k neurons in real-time
- GeNN can simulate **up 100k neurons** in **real-time on a state-of-the-art GPU**

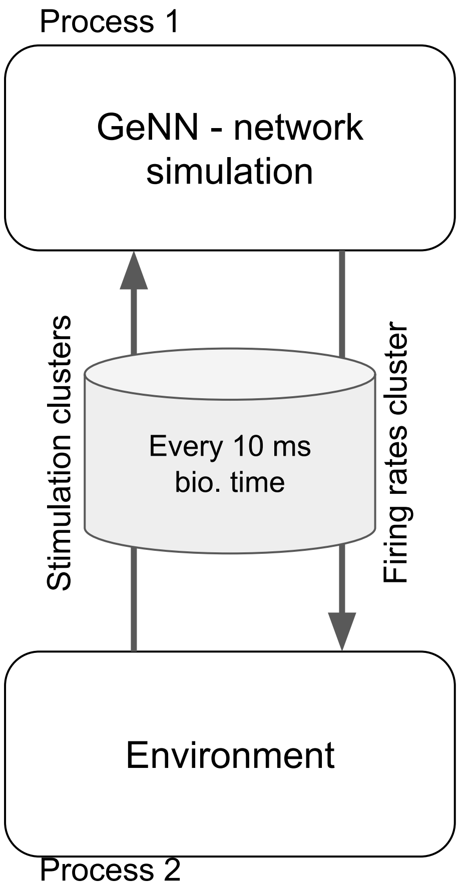


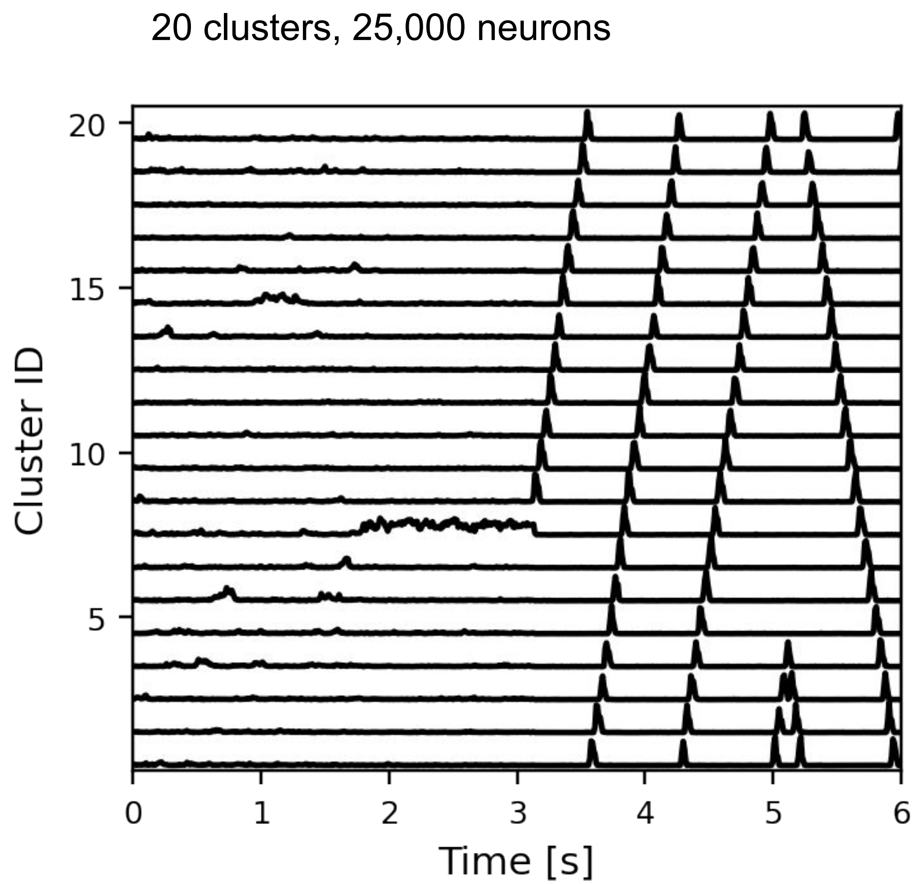
GeNN: closed-loop large-scale network



Average time per 10 ms loop: 108 ms

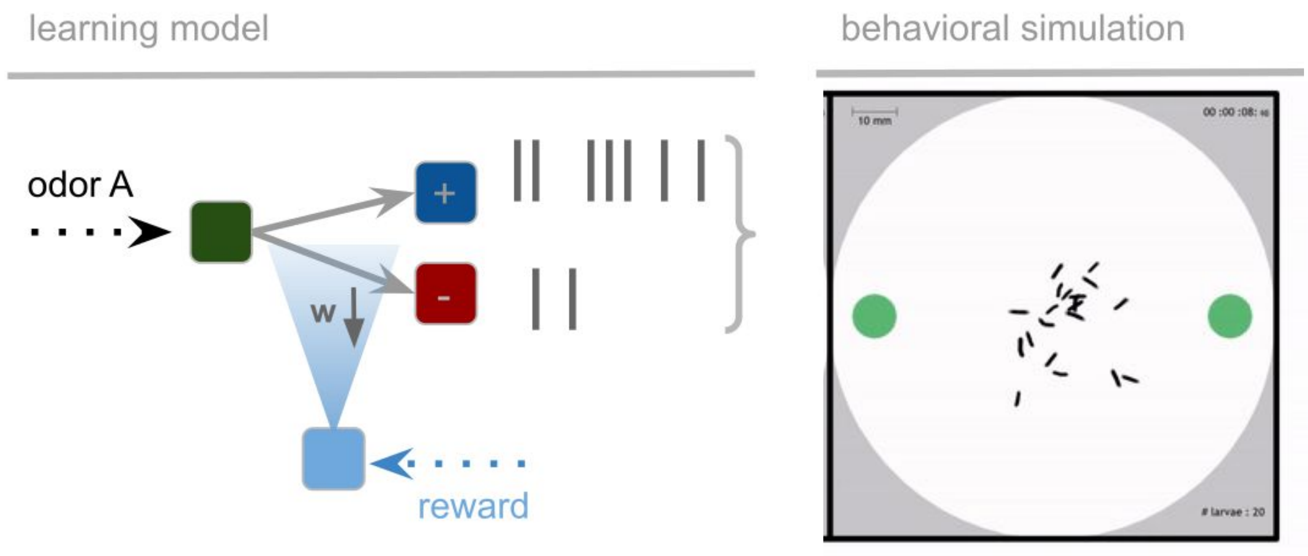
GeNN: closed-loop large-scale network





Average time per 10 ms loop: 108 ms

Challenge: Associative learning in insects



- Challenge: small network with 140 neurons has to be simulated over long periods (~30 minutes)

[Jürgensen, Sakagiannis in preperation]

Conclusion

- GPU based simulation with **GeNN is in advantage for large network size or real-time simulation**
- CPU based simulation with **NEST is ideal for prototyping with easy access to the non-expert programmer**

Thank you for your attention.

I especially thank James Knight for his help with GeNN.

References:

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[Knight et al. 2021]	Knight, J. C., Komissarov, A., & Nowotny, T. (2021). PyGeNN: A Python Library for GPU-Enhanced Neural Networks. *Frontiers in Neuroinformatics*, *15*.