Laboratory for Parallel Programming

Bachelor's / Master's Thesis

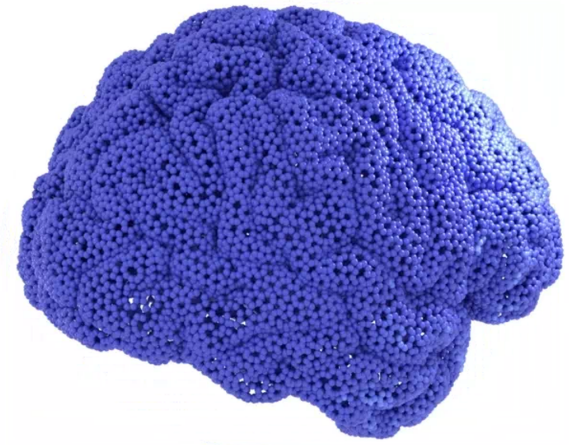
TECHNISCHE UNIVERSITÄT DARMSTADT

Parallel Programming

Rolling call: High-performance simulation of structural plasticity in the brain

Motivation

Our group develops a high-performance simulation for structural plasticity in the brain, i.e., a model that describes how neurons form new synapses over time. The approach to solving the pairwise interaction of neurons relies on the Barnes–Hut algorithm, an approximation originally from astrophysics [1, 2]. Synaptic changes do not only happen in children – various stimulations (learning, diseases, etc.) can alter the connectivity in the brain, even for adults. However, classical neuroscientists have a degree in biology or physics and thus do not have the experience to develop efficient and scalable simulations, so we are working on this topic "on the computer science side".



A visualization of a (scan of a) human brain with approximately 50 000 neurons.

Task

As this is a rolling call, there are no fixed tasks to report here. You can approach us, and we can figure out together what might best suit you and your interests. Possible directions are:

- Other approximations for the pairwise interactions/communication algorithms.
- Structural improvements to the code (e.g., different data structures allowing faster computations).
- Porting code to new architectures and analyzing performance bottlenecks (e.g., using CUDA).
- Implementing models for memory, diseases, etc.

Requirements

- C++ and Python (split depending on topic)
- Depending on the topic: MPI, CUDA, OpenMP, ...

Contact

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References

1. Rinke, S., Butz-Ostendorf, M., Hermanns, M.A., Naveau, M., & Wolf, F. (2018). A Scalable Algorithm for Simulating the Structural Plasticity of the Brain. Journal of Parallel and Distributed Computing, 120, 251–266.
2. `https://www.1730live.de/wissenschaftler-wollen-gehirn-nachbauen/`

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