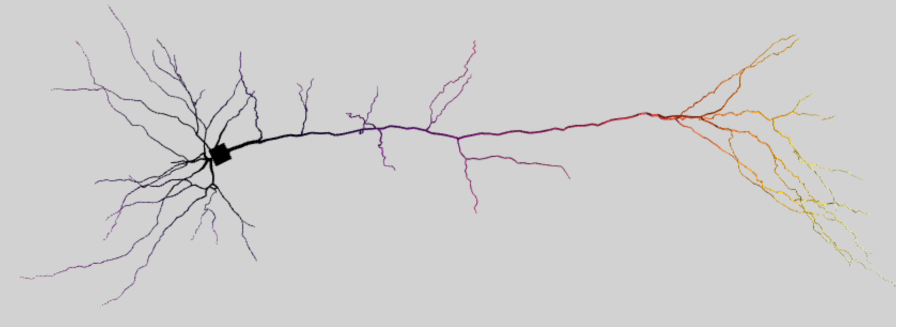

ARBOR
AN INTRODUCTION

June 2024 | H. Lu, **T. Hater** | SDL Neuroscience | Forschungszentrum Jülich

Zooming In

From Points to Dendrites

Def.: Point

The (adult) human eye has a resolution of roughly $30\mu m$.

Thus going from a point to a typical neuron — a pyramidal cell — with dimensions of $10\mu m$ (soma) – $1\mu m$ (axon), we need to magnify by $3 - 30\times$.

At this level, we can model the electrical processes within a cell and resolve the distribution of dynamics across the cell's surface.

Cells will still communicate using action potentials.

- Design goals:
  Usability, performance portability, and strong separation of concerns.
- Made to exploit Multicore, SIMD, and GPU
- Scales extremely well: 768 nodes $\times$ 4 A100 on JUWELS booster. 70 Million cells.
- HBP since 2016 by CSCS and FZJ
- C++17 and Python3
- Linux and MacOS
- FOSS with a permissive BSD3 license
- Modern dev cycle in the open:
  Git, Code Review, CI, tests, sanitizers, …

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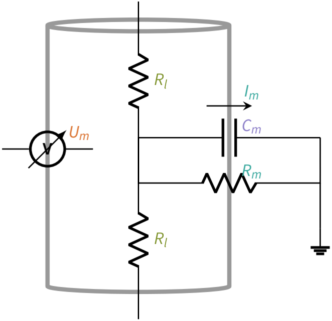
The Bio-Physical Model

Consider a cell as a bi-lipid membrane suffused with ion channels, gating proteins, separating charged solutions of ions.

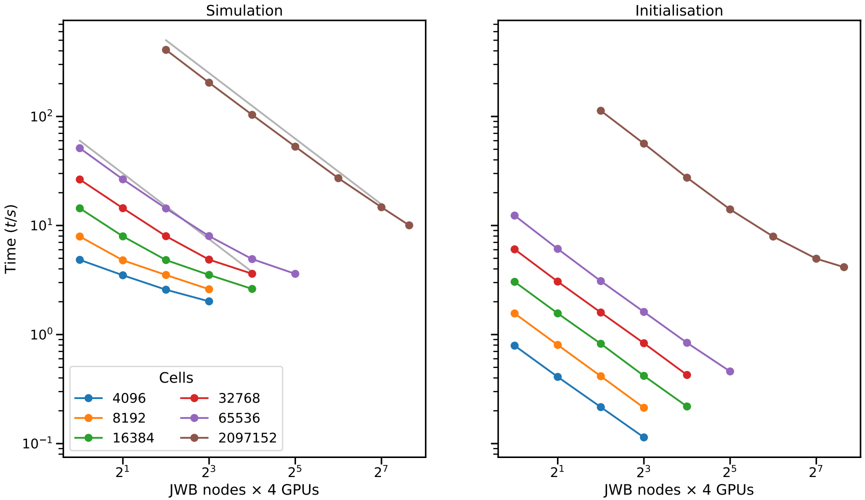
$$C_m \partial_t U_m = \partial_x \left(\frac{1}{R_l} \partial_x U_m \right) + I_m$$



- C_m: Membrane capacitance.
- I_m: Transmembrane current.
- U_m: Membrane potential.
- R_l: axial resistance.

The interplay of ion channels, in particular their dependence on the the membrane potential, creates action potentials and dynamics of the cells.

Performance



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