Modelling Memory Across Scale

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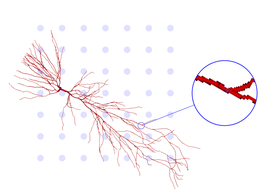
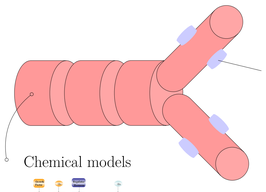
Introduction

- Memory and plasticity involve brain mechanisms from molecular scale to enormous networks.
- We have developed MOOSE the Multiscale Object Oriented Simulation Environment, to model plasticity across scales.



Embed in network



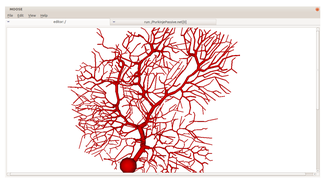
Chemical models

Trafficking models

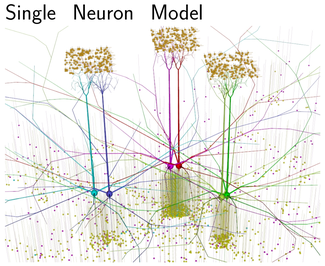
Multiscale Modeling in

Why multiscale?

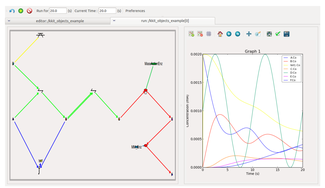
- 10^{11} cells
- 10^{15} synapses
- $10000?$ reactions per synapse
- Electrical events: < 1 ms
- Chemical events: 1 sec $\rightarrow 1000$ sec
- Structural events: 100 sec $\rightarrow$ months
- Lifetime of a protein: days
- Lifetime of a neuron: 100 years
- Lifetime of a memory: 100 years



Single Neuron Model

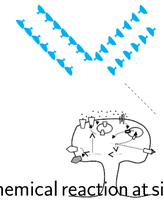


Olfactory bulb network

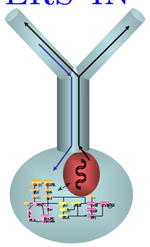


Signalling Model

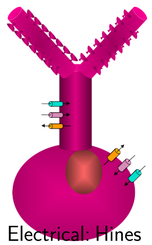
Modular Solvers in



Chemical reaction at single molecule level



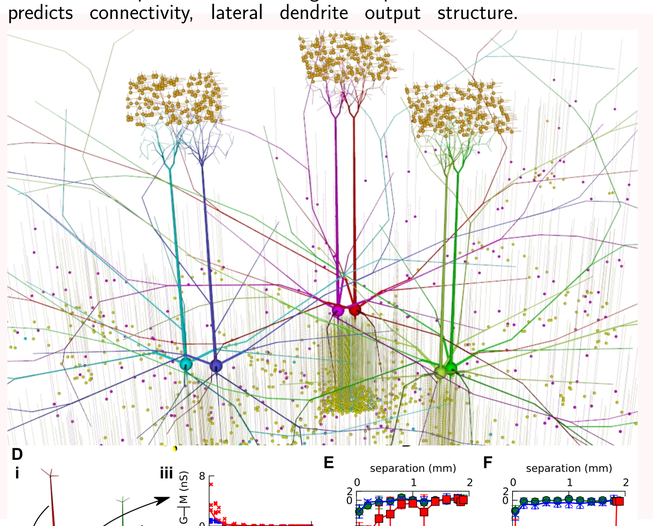
Reaction Diffusion Solver

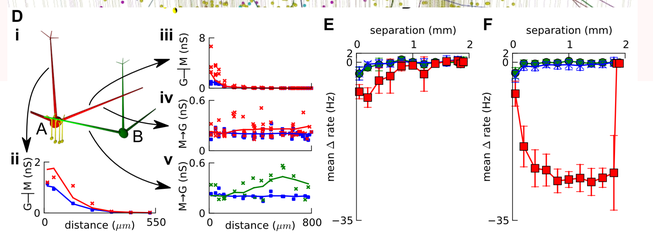


Electrical: Hines Solve

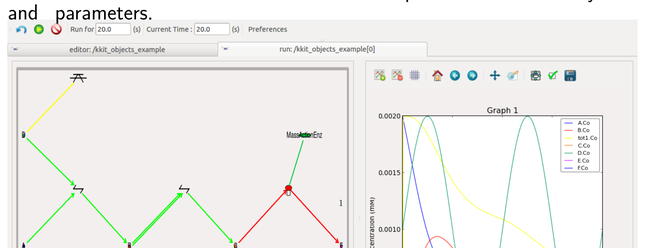
Some projects using

Network coding and computation in olfaction and sematosensory cortex. It explains linear coding and phase-decorrelation and predicts connectivity, lateral dendrite output structure.





Robustness of chemical switches with respect to stochasticity and parameters.



Summary

We use models to

- Integrate many scales of neuronal data with basic physical/chemical principles.
- Explain phenomenon of plasticity, activity and neuronal coding.
- Predict circuit mechanisms, plasticity rules, and emergent phenomena such as *decorrelation*, *robustness*, and *memory decay*.

We have developed MOOSE to carry out these simulations.