Simulating dendrites at different levels of abstraction (SmartNets tutorial)

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Session 1: Introduction to computational modeling (09:00-09:30)

Session 2: Create and validate a point IF model in Brian2 (09:30-10.30)

1. Learn how to specify model equations and parameters
2. Core Brian2[1] classes: NeuronGroup, Synapses, Monitors.
3. Running simulations and access/process output.
4. How do we validate a neuronal model?

Coffee break (10:30-11.00)

Session 3: Adding dendrites to Brian2 (the hard way) (11.00-13.00)

1. Connecting multiple compartments - Cable equation[2]
2. Show key benefits of multi-compartmental models (electrical segmentation, semi-independent computing, coexistence of multiple integration sites)

Session 4: Short Dendrify[3] tutorial (13.00-13.00)

Lunch break (13.30-15.00) – FORTH cafeteria

Session 5: Biophysical models and HH formalism (15.00-15.30)

Session 6: Introduction to NEURON[4] with python (15.30-17.00)

1. Build a two-compartment model
2. Passive properties
3. Active properties (mod files)
4. Synapses (NetStim, NetCon, VecStim)

Coffee break (17.00-17.30)

Session 7: Simulating dendrites (17.30-19.30)

1. How inputs propagate to the soma and how they interact
2. Segregated dendrites
3. Integrating inputs with active dendrites
4. How inputs interact in time
5. Coincidence detection in the apical tree through calcium spike (BAC model[5])

19.30: Dinner at Merastri restaurant

Reading materials

Stuart G, Spruston N, Hausser M (2008). Dendrites. Oxford Univ Press.

[1] Brian2: https://brian2.readthedocs.io/en/stable/
[2] Cable theory: http://www.scholarpedia.org/article/Neuronal_cable_theory
[3] Pagkalos et al., 2022, bioRxiv, doi: https://doi.org/10.1101/2022.05.03.490412
[4] NEURON: https://nrn.readthedocs.io/en/latest/index.html
[5] Schaefer et al., 2003, *J Neurophysiol*, doi: https://doi.org/10.1152/jn.00046.2003

Gerstner W, Kistler WM, Naud R, Paninski L (2014). Neuronal dynamics: From single neurons to networks and models of cognition. Cambridge Univ Press.
Sterratt D, Graham B, Gillies A, Willshaw D. (2011). Principles of computational modelling in neuroscience. Cambridge Univ Press.
Ermentrout B, Terman DH. (2010). Mathematical foundations of neuroscience. New York: springer.