

On Dendro-dendritic Coupling

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March 22, 2024

Abstract

In this note, the authors present a first look at coupling between dendritic arbors. They consider a cell body surrounded by a spherically emanating dendritic arbor. They discuss the coupling equation for N such cells with arbors.

For a certain class of dendritic arbors Wilfrid Rall has derived, and it is well known (see [1] and related references), that the entire arbor can be modeled as a single cable. Since it is a dendritic arbor and not an axon, there are no nodes where an “action potential” is initiated. In [2] it was shown that a myelinated axon has nodes and internodes, with both the equations being jointly representable. In this paper we will restrict our attention to the internode cable equation, inclusive of geometry. This equation is re-presented here for convenience:

$$C_i \frac{\partial V_i}{\partial t} = \kappa \frac{\partial^2 V_i}{\partial x^2} + \sum_{k \neq i} s_k \frac{\partial^2 V_k}{\partial x^2} - \xi G V \quad (1)$$

Note that there is no ionic or injected current term.

This multi-axon equation is derived taking into account the extracellular potential, which Rall neglected as an assumption to simplify the dendritic case. Since it does take the extracellular potential into account, and the dendritic arbor as a whole is just a single cable, we may couple multiple such arbors in the same way as was done in the aforementioned multi-axon equation. In future work we hope to present some simulations. These would be interesting if individual branch voltage profiles can be related to Rall’s single cable representation.

References

- [1] Christof Koch and Tomaso Poggio. A simple algorithm for solving the cable equation in dendritic trees of arbitrary geometry. *Journal of neuroscience methods*, 12(4):303–315, 1985.
- [2] Aman Chawla, Salvatore Morgera, and Arthur Snider. On axon interaction and its role in neurological networks. *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, 2019.

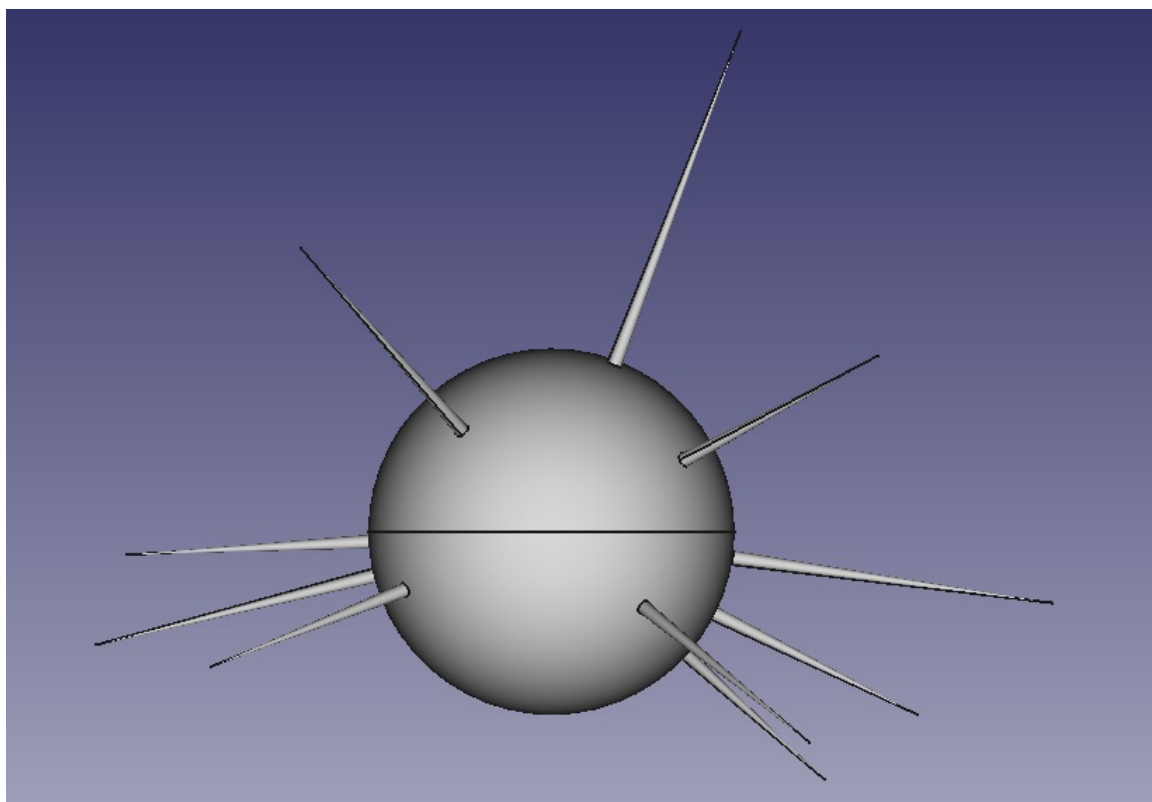


Figure 1: Soma with dendrites.