

Modeling the Saltatory Conduction in Myelinated Axons by Order Reduction

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Abstract : The saltatory conduction is the way the action potential is transmitted along a myelinated axon. The potential diffuses along the myelinated compartments and it is regenerated in the Ranvier nodes due to the ion channels allowing the flow across the membrane. For an efficient simulation of populations of neurons, it is important to use reduced order models both for myelinated compartments and for Ranvier nodes and to have control over their accuracy and inner parameters. The paper presents a reduced order model of this neural system which allows an efficient simulation method for the saltatory conduction in myelinated axons. This model is obtained by concatenating reduced order linear models of 1D myelinated compartments and nonlinear 0D models of Ranvier nodes. The models for the myelinated compartments are selected from a series of spatially distributed models developed and hierarchized according to their modeling errors. The extracted model described by a nonlinear PDE of hyperbolic type is able to reproduce the saltatory conduction with acceptable accuracy and takes into account the finite propagation speed of potential. Finally, this model is again reduced in order to make it suitable for the inclusion in large-scale neural circuits.

Keywords : action potential, myelinated segments, nonlinear models, Ranvier nodes, reduced order models, saltatory conduction

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