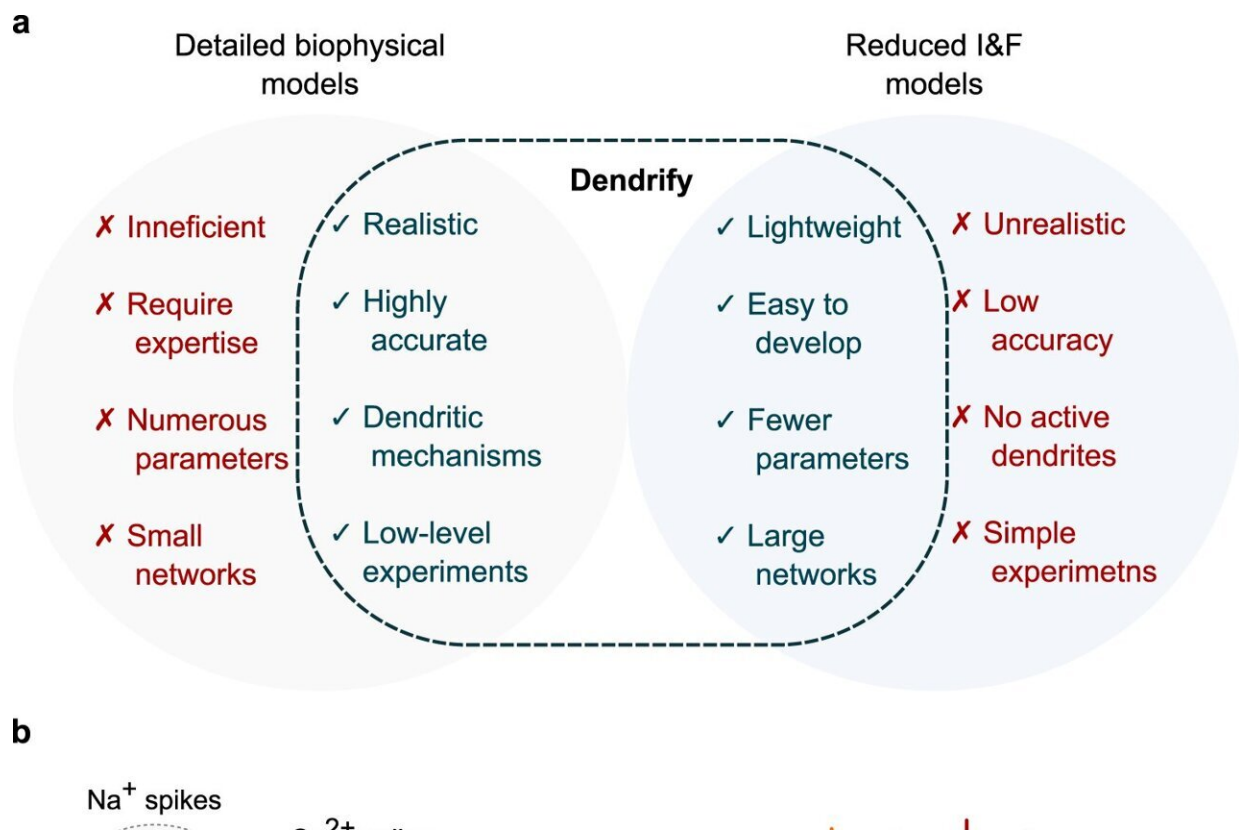# New software incorporates dendritic properties into neural network models

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The main characteristics of dendrify. a) Dendrify stemmed from our efforts to bridge the gap between detailed biophysical models and reduced I&F models. The result is a modeling framework for developing simplified compartmental models that balance efficiency and biological accuracy by capturing the most important characteristics of both worlds. b) Dendrify facilitates the development of SNNs comprising reduced compartmental neurons (ball and sticks) and known dendritic phenomena, such as various types of local spikes (Color code; teal: Na^+ spikes, red: Ca^{2+} spikes, orange: NMDA spikes. Scale bar: 20 mV/10

FORTH-IMBB researchers have developed innovative computational tools to unravel the role of dendrites; complex neuronal brain structures with a key role in information processing. The new software allows the incorporation of important dendritic properties into neural network models. This work has important applications both in understanding brain function and in the field of artificial intelligence.

Deciphering the secrets of the brain is considered to be one of the most important scientific endeavors of the 21st century. A better understanding of the mechanisms underlying brain function will contribute to research on the treatment of neurological diseases as well as the field of artificial intelligence, which has become an integral part of our society.

In a recent publication, in *Nature Communications*, the team of Dr. Panayiota Poirazi, a Research Director at the Institute of Molecular Biology and Biotechnology (IMBB) of the Foundation for Research and Technology-Hellas (FORTH), presents a new software framework that allows the incorporation of dendrites and their key mechanisms into large-scale neural network models.

Dendrites are the branched extensions of nerve cells that morphologically resemble the branches of a tree (hence their name). Their main function is to receive information from other neurons (in the form of electrical or chemical signals) and transmit it to the main body of the cell. For decades since their discovery, their role in information processing remained unknown, due to technological limitations in research.

But recent studies reveal that dendrites have a wealth of mechanisms that allow them to perform complex mathematical calculations independent of the main neuron. At the same time, dendrites are equally important for the plasticity of the nervous system, i.e., the ability of the brain to change and adapt to its environment. This process plays a dominant role in complex brain functions, such as learning, memory, decision making and cognition.

Although we now largely understand the contribution of dendrites to the behavior of a single neuron, their implications at the level of networks or entire brain regions remain unexplored. A small number of studies correlate dendritic complexity with various cognitive markers, and dendrites are known to decline during aging or in neurodegenerative diseases such as Alzheimer's. In addition, research on AI has already benefited from the use of dendritic mechanisms as a source of inspiration for the development of new improved and more efficient algorithms. However, many open questions remain and Dr. Poirazi's team hopes that the tools they are developing will facilitate the work of those attempting to understand the role of dendrites in brain function.

This study introduces a new software framework that allows even naive users to build neuronal models with dendrites in a simple and efficient manner, thus minimizing computational complexity. Such computational models help to elucidate the role of dendrites in complex brain functions while also facilitating their incorporation in neuromorphic devices, a type of neuro-inspired artificial intelligence architecture.

This effort was led by Michalis Pangalos, Ph.D. candidate in the Department of Biology of the University of Crete, in collaboration with Dr. Spiros Chavlis, postdoctoral researcher at IMBB, under the supervision of Dr. Poirazi.

More information: Michalis Pagkalos et al, Introducing the Dendrify

framework for incorporating dendrites to spiking neural networks, *Nature Communications* (2023). DOI: 10.1038/s41467-022-35747-8

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