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# Artificial Brains for Artificial Intelligence: A Novel Neurophysically Inspired Neural Network

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Artificial neural networks (ANNs) are capable of complex feature extraction and classification with applications in robotics, natural language processing, and data science. Yet, many ANNs have several key limitations; notably, current neural network architectures require enormous training datasets and are computationally inefficient. It has been posited that biophysical computations in single neurons of the brain can inspire computationally more efficient algorithms and neural network architectures. Recently, research on dendrites, including work from our lab, suggests that each biological neuron is endowed with a hidden subcellular computational power more complex than the conventional perceptron providing a promising substrate for more efficient ANNs.

To this end, we propose the Interconnected Dendritic Network (IDN), a new type of ANN that takes close inspiration from cellular and subcellular networks of pyramidal neurons. Each neuron in an IDN has a set of dendrites that receive inputs; these dendrites are subdivided into branches of multiple orders to closely mimic dendritic organization in biological neurons. We further employ a family of physiologically-inspired activation functions to characterize neuronal input-output transformations. Instead of discrete layers, neurons are arranged in an n-dimensional space following topographical connectivity rules, forming a recurrent network. The network is composed of both excitatory and inhibitory neurons, which act in unison to regulate network activity. Learning happens by altering synaptic weights based on Hebbian plasticity, approximating synaptic weight distributions observed in biological networks. The IDN reached over 95% accuracy on written digit classification after training on only 400 data points and utilizing 3.6% of computational operations compared to a traditional dense model performing the same task with similar performance. Additionally, we show that the IDN is capable of predicting the motion of simulated physical systems in a reservoir-computing paradigm. Thus, we present a model that performs in low-data applications, is computationally efficient, and utilizes biophysically grounded mechanisms to mitigate the limitations of current ANNs.

## Focus areas

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