บทคัดย่อ

CORTEX 4.2: A De Novo Artificial Connectome Framework for Biologically Inspired Neural Modeling and Adaptive Behavior

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Neuromorphic artificial intelligence, neuroprosthetics, and brain–computer interfaces have advanced rapidly in recent years. However, computational tools that can represent biologically meaningful neural structures while remaining practical to run on personal computers are still limited. Experimental neuroscience requires expensive wet-laboratory facilities, while conventional artificial intelligence systems usually lack biological structure, neural timing, and continuous online adaptation. Existing platforms may focus mainly on computational efficiency, while large-scale brain reconstruction projects require extensive data and high-performance computing resources. CORTEX 4.2 is developed as a Python- and PyTorch-based brain-inspired simulation framework for constructing a de novo artificial connectome, meaning an artificial neural system built from biological knowledge rather than copied from a complete measured brain. The framework preserves key biological components, including conductance-based spiking neurons, dendritic processing, simplified AMPA, NMDA, GABA-A, and GABA-B synaptic dynamics, astrocyte regulation, neuromodulators, neural oscillations, and activity-dependent plasticity. These components are integrated into simplified brain regions and functional neural pathways for sensory processing, action selection, reinforcement learning, hippocampal spatial coding, associative memory, sequence memory, and synthetic EEG generation. CORTEX 4.2 is not intended to reconstruct a complete biological brain or claim full biological accuracy. Instead, it aims to provide an accessible platform for building, connecting, testing, and studying biologically inspired neural systems. The framework serves as a bridge between neuroscience and engineering, allowing researchers and students to explore how simplified biological mechanisms can support learning, memory, neural activity, and adaptive behavior on conventional computing hardware.