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ATP Restriction Influences Outcomes in Brain-in-a-Dish Models Utilizing EDLIF and ED-STDP

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Biological neurons are remarkably energy-efficient, capable of performing complex computations with minimal energy consumption. Understanding these mechanisms can inform the design of efficient computational models and energy-aware learning systems. In this study, we implemented energy-dependent neuron and synaptic plasticity models—EDLIF (Energy-Dependent Leaky Integrate-and-Fire) and EDSTDP (Energy-Dependent Spike-Timing-Dependent Plasticity)—using NEST. We developed a simulated environment/arena in NEST where a network of biophysically plausible artificial neurons control a two-wheeled robot that learns to avoid obstacles based on proximity sensor data. Our network, driven by synaptic plasticity, learned to steer away from obstacles based on sensory input. We further observed that modifying ATP-related parameters significantly affected performance, suggesting that the task's success is closely tied to energy availability and usage. These results emphasize the role of metabolic constraints in learning and offer insights for the development of energy-efficient neuromorphic systems.

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References

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