Abstract Information

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Participation :	symposium
Title of the Symposium :	Recent advances at the interface of neuroscience and AI (NeuroAI)
Category :	Invited Speakers
Thematic Area :	Computational, and Theoretical Neuroscience
Title :	Improving the adaptive and continuous learning capabilities of artificial neural networks using multi-scale, neuromodulation-aware rules

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Abstract :

Continuous, adaptive learning?the ability to constantly adjust to changing environments and improve performance?is a defining feature of both natural and artificial intelligence. Biological organisms excel in acquiring, transferring, and retaining knowledge while adapting to dynamic conditions, making them a rich source of inspiration for artificial neural networks (ANNs). Although the underlying principles of the biological brain have inspired the development of learning algorithms for ANNs, physiological processes such as neuromodulation are typically oversimplified in these models.

Neuromodulators like dopamine (DA), acetylcholine (ACh), serotonin (5-HT), and noradrenaline (NA) play a critical role in brain function, operating at multiple scales to facilitate adaptive responses to environmental changes. These neuromodulatory processes range from local synaptic plasticity to global network-wide adaptations, allowing for flexible, context-dependent learning. Notably, the relationships between neuromodulators and their roles in modulating sensory and cognitive functions are more complex than previously thought, involving intricate "many-to-one" mappings between neuromodulators and tasks.

This talk will focus on the following key areas:

1. How multi-neuromodulatory interactions enrich single-neuromodulator-driven learning.
2. The impact of neuromodulators across different spatial and temporal scales.
3. Strategies for integrating or approximating neuromodulatory learning processes in ANNs.

I will begin with a brief overview of past and current efforts to incorporate multi-scale neuromodulatory components into computational models, highlighting how these efforts have enabled more flexible and adaptive learning in behavioral tasks. Next, I will present my research on integrating multi-scale, parallel neuromodulatory mechanisms into ANNs, with insights drawn from both behavioral experiments and single-unit recordings. I will then illustrate how neuromodulation-inspired mechanisms, such as DA-driven reward processing and NA-driven cognitive flexibility, can enhance ANN performance in a Go/No-Go task. Finally, I will outline key directions for future research.

In conclusion, by incorporating multi-scale neuromodulation, we aim to bridge the gap between biological learning processes and artificial systems, ultimately enabling ANNs with greater flexibility, robustness, and adaptability.