Frequency Switching Neuristor Emulating Neuronal Intrinsic Plasticity

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The human brain's remarkable information processing efficiency and adaptability stem largely from spatiotemporal spiking activities and intrinsic plasticity, the ability of individual neurons to autonomously modulate their excitability. While Mott memristors, leveraging their threshold switching, have been effectively employed as artificial neurons to generate spiking patterns, the hardware implementation and functional significance of intrinsic plasticity in neuromorphic computing remain largely unexplored. Here, we introduce a frequency switching (FS) neuristor specifically designed to emulate this crucial neuronal characteristic. By integrating a volatile Mott memristor with a non-volatile valence change memory (VCM) element, the FS neuristor exhibits programmable, multi-level frequency-voltage relationships directly analogous to the adaptive transfer functions of biological intrinsic plasticity. Device-based simulations of sparse neural networks demonstrate that this embedded plasticity acts as a computational element, enhancing network performance and significantly reducing energy consumption. Moreover, it imparts structural resilience, enabling networks to fully recover performance even after random neuron loss. This work presents a pathway toward developing more adaptive and robust neuromorphic computing systems by harnessing intrinsic plasticity.

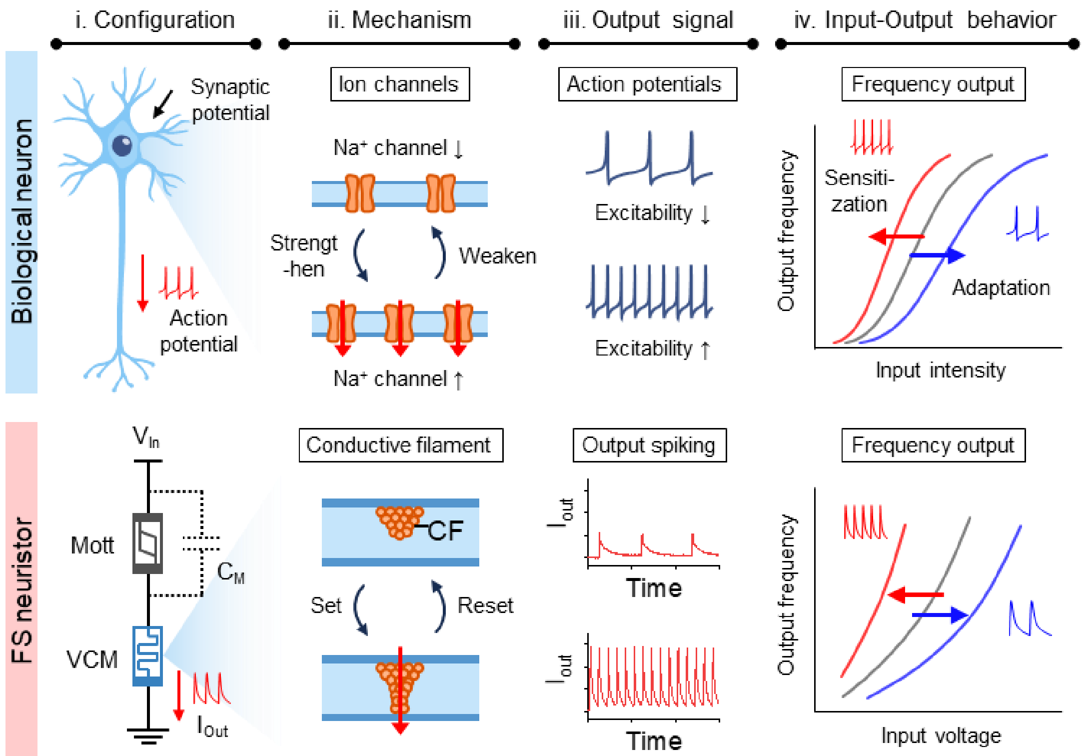

Figure 1: Comparison of a biological neuron and the frequency switching neuristor .

[1] W. Park et al., Adv. Mater., 37 (44), e202255, 2025.