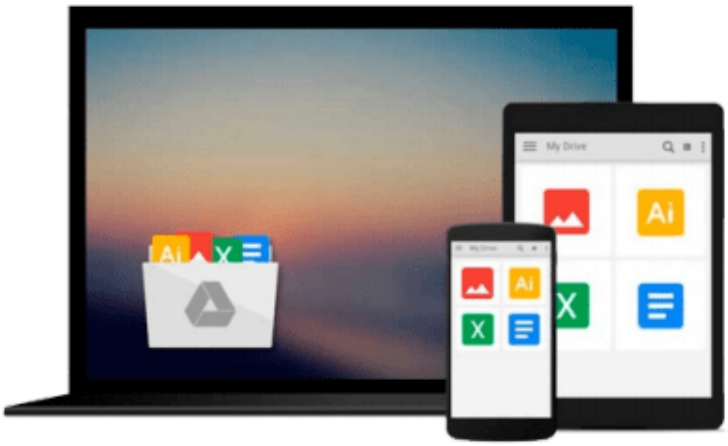

Engineered Biomimicry: Chapter 2. Noise Exploitation and Adaptation in Neuromorphic Sensors

Thamira Hindo, Shantanu Chakrabartty

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Even though current micro-nano fabrication technology has reached integration levels at which ultra-sensitive sensors can be fabricated, the sensing performance (bits per Joule) of synthetic systems are still orders of magnitude inferior to those observed in neurobiology. For example, the filiform hair in crickets operates at fundamental limits of noise and energy efficiency. Another example is the auditory sensor in the parasitoid fly Ormia ochracea that can precisely localize ultra-faint acoustic signatures in spite of the underlying physical limitations. Even though many of these biological marvels have served as inspirations for different types of neuromorphic sensors, the main focus of these designs has been to faithfully replicate the biological functions, without considering the constructive role of noise. In manmade sensors, device and sensor noise are typically considered nuisances, whereas in neurobiology noise has been shown to be a computational aid that enables sensing and operation at fundamental limits of energy efficiency and performance. In this chapter, we describe some of the important noise exploitation and adaptation principles observed in neurobiology and how they can be systematically used for designing neuromorphic sensors. Our focus is on two types of noise exploitation principles, namely, (a) stochastic resonance and (b) noise shaping, which are unified within a framework called ΣΔ learning. As a case study, we describe the application of ΣΔ learning for the design of a miniature acoustic source localizer, the performance of which matches that of its biological counterpart (O. ochracea).

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