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Stable learning in networks of unreliable, memristive nanodevices

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Abstract
Neuromorphic circuits—electronic circuits emulating the functionality of the brain—have teased us for fifty years with their potential for creating autonomous, intelligent machines that can adaptively interact with uncertain and changing environments. Although there are many stumbling blocks to achieving that vision, a primary problem has been the lack of a small, cheap circuit that can emulate the essential properties of a synapse. Brains require synapses, and lots of them (an estimated 10^{14} in the human brain), but only about 1/10000 as many neurons, so synapse circuit design dominates the implementation problem. Memristive nanodevices may fill the role of an electronic analog of biological synapses: they are essentially analog memories that can be switched between extreme states in 20 nanoseconds or less, yet maintain their state for years when power is removed. They can also be manufactured at biological scale densities (more than 10^{10} devices per cm^2) and integrated with conventional CMOS. In this talk I will present some neuromorphic nano/CMOS architectures along with corresponding simulations showing how memristive nanodevices fabrics can be integrated with conventional CMOS circuitry to form networks capable of stable learning in changing environments, even though the nanodevices themselves show large variations in electrical properties. The circuits, like biological brains, are inherently defect-, fault-, and failure-tolerant.