2D Material-based Smart Sensors and Computing Devices for Hardware Artificial Intelligence

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Abstract: Many animals outsmart humans in sensory skills. Drawing inspiration from natural intelligent and exploiting unique electronic and optoelectronic properties of atomically thin two dimensional (2D) semiconductors (***Nature Communications**, 12, 693 2021*), we develop next-generations of high performance, ultra-low-power, flexible, reliable, artificially intelligent, radiation tolerant and inherently secure solid state computing devices and Internet of Things (IoT) sensors. We not try to improve the detection threshold, range, latency, and energy efficiency of next generations of remote sensors, by orders of magnitudes, but also integrate sensing, storage, and processing capabilities on a single hardware platform to overcome the von Neumann bottleneck of current CMOS technology. We have already developed a number of biomimetic devices that provide unprecedented energy and area benefits for sensory computations. In particular, we have mimicked auditory information processing in barn owl (***Nature Communications**, 10, 3450, 2019*), collision avoidance by locust (***Nature Electronics**, 3, 646–655, 2020*), and subthreshold signal detection by paddlefish and cricket using stochastic resonance (***Nature Communications**, 11, 4406, 2020*). We have also mimicked probabilistic computing in animal brains using low-power Gaussian synapses (***Nature Communications**, 10, 4199, 2019*), high precision neuromorphic computing using graphene memristors (***Nature Communications**, 11, 5474, 2020*), and realized a biomimetic neural encoder for spiking neural networks (***Nature Communications**, 12, 2143, 2021*). We use in-memory computing architectures to demonstrate this new paradigm of sensing and computing. Our goal is to deploy theses low-power and smart