In materia computing: physical laws and nanodevices for brain-inspired information processing

Abstract for the MLDM Workshop of the AIxIA Conference

Gianluca Milano*[1] and Carlo Ricciardi[2]

1 INRiM (Istituto Nazionale di Ricerca Metrologica), Strada delle Cacce 91, 10135 Torino, Italy.
2 Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Torino, Italy.
* corresponding author
g.milano@inrim.it, carlo.ricciardi@polito.it

Open Challenge contribution

Abstract

The growth of AI requires a hardware revolution to sustain the continuous growth of computing power demand, to reduce enormous costs and energy consumption required for computation [1]. In this framework, the implementation of unconventional computing paradigms in brain-inspired emerging hardware technologies can represent a breakthrough for future computing technologies. Here, principles of physical reservoir computing will be discussed, highlighting how physics of emerging nano devices can be exploited for computing through physical laws directly at the matter level, i.e., for *in-materia* computing. Besides providing examples of physical substrates for computing, main concepts for building a physical reservoir will be discussed by exploiting neuromorphic memristive nanowire networks as a case study [2]. It will be shown through an experimental and modeling approach that these nanowire networks represent a computational substrate that allows the emulation of a wide range of brain-like functionalities, including short-term plasticity, long-term plasticity, structural plasticity, and heterosynaptic plasticity [3]. In addition, we show that these networks allow the emulation of memory engrams (or memory traces), i.e., physicochemical changes in biological neural substrates supposed to endow the representation of experience stored in our brain [4]. The exploitation of these brain-like functionalities for *in-materia* computing will be discussed, together with open challenges for the development of emerging neuromorphic computing technologies.

References

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