Neuromorphic computing in Ginzburg-Landau polariton lattice systems

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The availability of large amounts of data and the necessity to process it efficiently have led to rapid development of machine learning techniques. To name a few examples, artificial neural network architectures are commonly used for financial forecasting, speech and image recognition, robotics, medicine, and even research. However, efficient hardware implementation is still lacking, since the most developed computing technologies available have been designed for the von Neumann architecture. Reservoir computing (RC) is a recent and increasingly popular bio-inspired computing scheme which holds promise for an efficient temporal information processing [1]. We demonstrate the applicability and performance of reservoir computing in a general complex Ginzburg-Landau lattice model, which adequately describes dynamics of a wide class of systems, including coherent photonic devices. In particular, we propose that the concept can be readily applied in exciton-polariton lattices, which are characterized by unprecedented photonic nonlinearity, opening the way to signal processing at rates of the order of 1 Tbit s^{-1} [2].

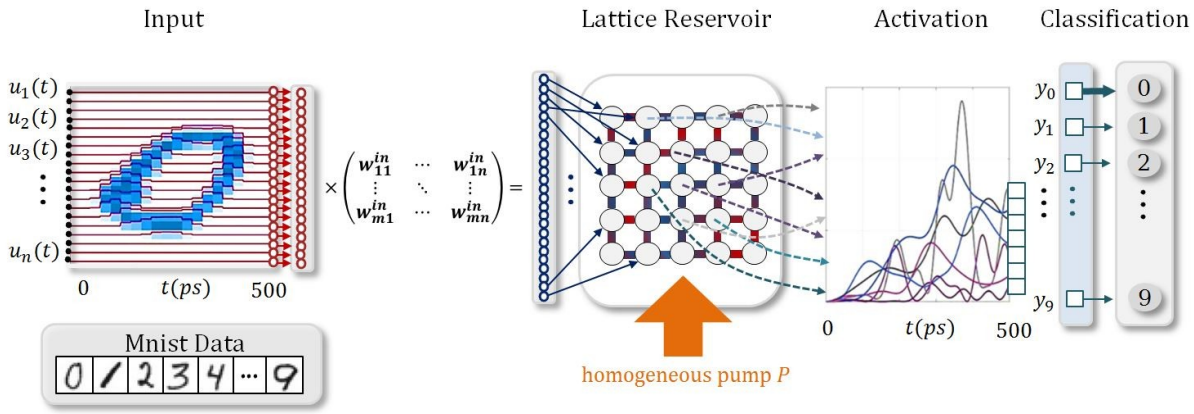

Fig. 1: Scheme for a handwritten digit classification task. Data is convoluted with random weights and imprinted on the lattice by driving each of the lattice sites. At the same time, the system is pumped to maintain a dynamic state close to the stability (or lasing) threshold. The resulting density in each node (activations) is recorded at the end of the sequence and used for classification of the input.

[1] G. Tanaka, T. Yamane, J. Benoit Héroux, R. Nakane, N. Kanazawa, S. Takeda, H. Numata, D. Nakano, and A. Hirose, "Recent Advances in Physical Reservoir Computing: A Review," arXiv:1808.04962 (2018).

[2] A. Opala, S. Ghosh, T. C. H. Liew and M. Matuszewski, "Neuromorphic computing in Ginzburg-Landau lattice systems", arxiv:1808:05135 (2018).