Reservoir computing with a silicon microring resonator matrix for image classification.

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ABSTRACT: In the development of hardware compatible and biologically plausible platforms, significant challenges emerge from the complexities of fully characterizing network states and programming network parameters. These hurdles hinder the application of conventional machine learning techniques, such as backpropagation [1,2].
To circumvent these problems, we propose a photonic integrated neural network, shown in figure 1, that is compact and easy to fabricate, consisting of silicon microring resonators interconnected by straight waveguides and linked to multiple input and output optical ports, similarly as in [3]. Notably, with only a few milliwatts of on-chip input power, this architecture exhibits rich recurrent nonlinear dynamics and both short- and long-term plasticity, due to the nonlinear effect of silicon based on free carriers and temperature [4-6]. Furthermore, our system benefits from the parallelism given by Wavelength Division Multiplexing.

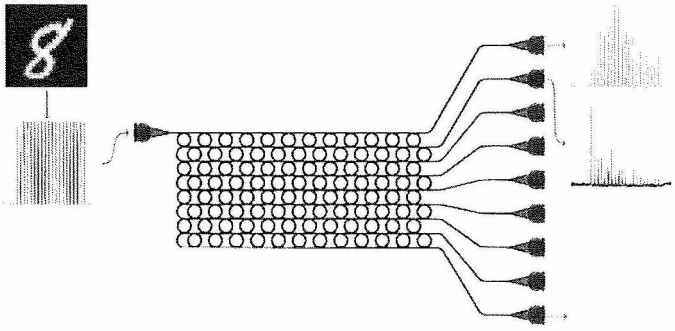

Figure 1: Processing of handwritten digits by an integrated photonic ANN. Images are flattened and inserted as an optical time series into the MRR matrix, which produces several nonlinear representations of the input, depending on the output physical port.

As a proof of concept, the MRR network is employed for handwritten digits classification (MNIST dataset [7]). In particular, the images are encoded into a time dependent signal, which is used to modulate a laser with a given power and wavelength (around 1550 nm). The resulting optical signal is injected into the left port of our integrated network, as shown in figure 1. Multiple nonlinear representations are measured at different physical output ports, on the right. Exploiting this microresonator matrix as a reservoir computer and linearly combining two or more nonlinear representations leads to improvements in the classification accuracy of the handwritten digits compared to the linear baseline case, corroborating the effectiveness of the proposed neuromorphic hardware.

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15:45-16:00 **O_14** Hybrid Plasmonic/Dielectric Nanostructured Devices Exhibiting High Sensitivity for Biosensing Applications
V. Nocerino, B. Miranda, P. Dardano, M.G. Manera, R. Rella, A. Colombelli, D. Lospinoso, L. De Stefano

S6 ARTIFICIAL INTELLIGENCE AND NEUROMORPHIC COMPUTING

14:30-16:00 Room: *002* *Chair: Andrea Barucci*

14:30-15:00 **INV_06** Silicon microresonators as spiking neurons for event detection
S. Biasi, A. Lugnan, L. Pavesi

15:00-15:30 **INV_07** Reservoir computing with a silicon microring resonator matrix for image classification
A. Foradori, A. Lugnan, L. Pavesi, P. Bienstman

15:30-15:45 **O_15** The ubiquity of Machine Learning in Biophotonics
G. Ciacci, C. D'Andrea, P. Matteini, M. Banchelli, E.M. Alessi, S. Di Ruzza, M.A. Pascali, S. Colantonio, A. Barucci

15:45-16:00 **O_16** Towards Digital Twin of Photonic Integrated Circuits: AI and Machine Learning Application for InP Mach-Zehnder Modulators Control
R. D'Ingillo, S. Straullu, R. Siano, V. Curri

16:00-16:30 Coffee Break

Parallel Sessions

S7 NETWORK AND TRANSMISSION

16:30-18:00 Room: *001* *Chair: Pierpaolo Boffi*

16:30-17:00 **INV_08** Metro-Access convergence scenario: Experimental Demonstration in an in-field 400 Gb/s Full Coherent Transmission
M. Casasco, A. Pagano, G. Rizzelli, V. Ferrero, R. Gaudino

17:00-17:30 **INV_09** AI-empowered Optical Network Self-Healing relying on the Digital Twin as-a-Service
R. Ambrosone, R. D'ingillo, V. Curri

17:30-17:45 **O_17** PDL Localization and Estimation through Longitudinal Power Monitoring: a Comparison between Least Squares and Correlation Methods
L. Andrenacci, G. Bosco, D. Pilori

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