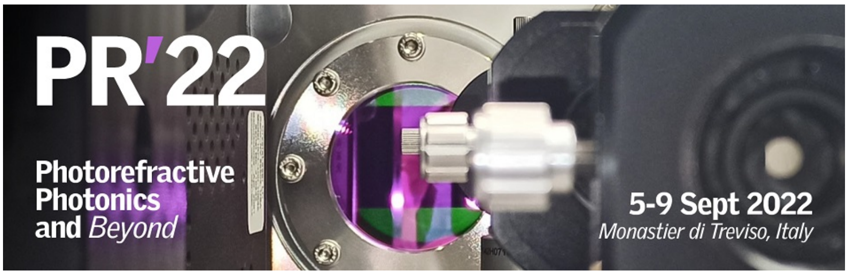

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Neural networking and machine learning based on photorefractive solitonic waveguides: novel all-plastic Photonic Artificial Intelligence

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Often, when speaking of artificial intelligence, we think of software systems capable of learning-memorizing-reasoning. All AI codes run on traditional computers, which suffer from architectures not optimized for neural computing: in fact, they are based on traditional von Neumann geometry, for which processing and memory areas are physically separated. Unlike computers, the brain uses a unified geometry (neuromorphic paradigm), whereby memory and computation occur in the same physical location. However, it is possible to create neuromorphic hardware systems for example using light. In the photonics field, one possible and efficient way is to use integrated circuits based on soliton waveguides, ie channels self-written by light. By exploiting photorefractive nonlinearity, light can write waveguides and subsequently modify them based on the information propagated within them. This feature makes this technique extremely promising as it introduces neuroplasticity into hardware systems, that is, the characteristic of biological brain of modifying itself plastically based on the transported information. The work proposed here introduces the soliton X-junction as an elementary unit (neuron) for complex neural networks. Solitonic X-junctions can learn in both supervised and unsupervised ways by unbalancing the junction according to the information carried. By exploiting this phenomenon, complex solitonic networks can store information as propagation trajectories and use them for reasoning. In fact, they can compare unknown data with the stored ones and eventually recognize them. Using the photorefractive nonlinearities in different materials, it is possible to create different types of memories with different peculiarities.

Authors: FAZIO, Eugenio (Dipartimento di Scienze di Base e Applicate per l'Ingegneria, Sapienza Università di Roma); BILE, Alessandro (Sapienza); TARI, Hamed (Sapienza university of Rome)

Presenter: FAZIO, Eugenio (Dipartimento di Scienze di Base e Applicate per l'Ingegneria, Sapienza Università di Roma)

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