
Programmable Photonic Integrated Processors for Free-Space Optical Links

Politecnico di Milano, Italy

Francesco Morichetti

Email: francesco.morichetti@polimi.it

As communication and computing architectures advance, there's a growing interest in utilizing analog processing in the optical domain to complement digital electronics. Photonic integrated processors have been recently proposed for various applications, including machine learning accelerators, cognitive radio, fiber optic signal processing, and optical quantum key distribution. In free-space optics (FSO), shaping and directing optical beams adaptively are essential tools for tasks like joint communication and sensing, positioning, and ranging. However, atmospheric conditions, obstacles, and the movement of transmitters and receivers can significantly affect the properties of the FSO link. This is especially crucial in multiple-input multiple-output (MIMO) FSO systems, where spatially multiplexed optical beams can enhance capacity but may suffer from mode orthogonality issues due to changing conditions. In this talk, I will present the use of photonic integrated processors made of programmable meshes of Mach-Zehnder Interferometers (MZIs) to efficiently generate, manipulate, and detect FSO beams with suitably tailored shapes [1,2]. This approach enables automated selection of optimal orthogonal MIMO communication channels across unknown media [3] and active mitigation of signal degradation caused by atmospheric turbulence using a photonic processor-assisted receiver [4].

[1] M. Milanizadeh, et al. *Photon. Res.* 9, 2196-2204 (2021)

[2] M. Milanizadeh, et al. *Light Sci Appl* 11, 197 (2022)

[3] S. SeyedinNavadeh, et al., *Nat. Photon.* 18, 149–155 (2024)

[4] S. SeyedinNavadeh, et al, *Optical Fiber Communications Conference (OFC) 2024*.



Short Bio:

Francesco Morichetti is Associate Professor at Politecnico di Milano, Dipartimento di Elettronica Informazione e Bioingegneria (DEIB) and Head of the Photonic Devices Lab of Politecnico di Milano (<https://photonics.deib.polimi.it/>). He has a twenty-year experience on optical devices and photonic integrated circuits for applications in fiber-optic and free-space optical communications, optical interconnects, computing and sensing. Current research topics include the design and control of programmable photonic integrated circuits for the implementation of analog (co)processors, hardware accelerators, adaptive beam shapers and wavefront sensors for free-space optical communications. He participated with leading roles in several international research programs. He is a member of the scientific panel of Spotlight on Optics (Optica), he serves as Specialty Chief Editor of Frontiers in Photonics, and he is in the technical committee of several international and national conferences. He is the author of 3 book chapters, more than 100 publications in international journals, more than 200 international conference proceedings and 10 international patents.