Applications of AI in nonlinear fiber optic

Goëry Genty[1], Mathilde Hary[1], Mehdi Mabed[2], Andrei Ermolaev[2], Daniel Brunner[2], and John M. Dudley[2]
[1]*Photonics Laboratory, Physics Unit, Tampere University, 33014 Tampere, Finland*
[2]*Institut FEMTO-ST, Université Bourgogne Franche-Comté CNRS UMR 6174, 25000 Besançon, France*
goery.genty@tuni.fi

Abstract: We will review recent advances in the use of machine learning for ultrafast nonlinear fiber-optics control and optimization.

The propagation of short and intense laser pulses in an optical fiber is known to be associated with a very rich landscape of nonlinear propagation scenarios and multidimensional dynamical regimes. For example, in the coherent regime, soliton dynamics can lead to the generation of a broadband supercontinuum while in the incoherent regime noise amplification can lead to the development of instabilities that have been associated with the emergence of extreme events. The dynamics can become even more complex in systems with spatially-extended degrees of freedom such as multimode fibers or systems with feedback such as fiber lasers. These can be challenging to model and control using conventional approaches. Recently, there has been rapid growth in the field of smart ultrafast photonics where machine-learning algorithms are combined with nonlinear optical systems allowing for optimized performance and control, high-speed characterization and identification of particular features within noisy data, or enhanced functionalities. In this talk, we will review our work in this area and, in particular, we will show how the techniques of machine learning can be efficiently exploited for the analysis of nonlinear instabilities and rogue waves; the prediction of complex supercontinuum generation dynamics with orders of magnitude increased computation speed when compared to conventional direct numerical integration of the generalized nonlinear Schrödinger equation; the optimized and precise control of the spectrum of broadband supercontinuum sources for spectroscopic applications and noise-like pulsed fiber lasers. We will also discuss our recent work where machine learning can be efficiently used for driven data analysis of complex nonlinear system, including the discovery of mathematical equations that underpins nonlinear propagation or identify the dominant terms along propagation in a nonlinear system.