Shaping light in all its states

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Abstract

We review a selection of recent results performed in our research institute based on the ability of light to perform control, nano-machining or computation operations in spatial or in temporal domain, in order to be applied widely in areas such as high-speed material processing with high resolution, computer micro-vision with digital holographic microscopy, and photonic neural networks implementation in hardware.

Laser light can be a powerful tool to machine materials at the nanoscale. The principles of digital holography can then be used for 3D spatial shaping of a laser beam such as Bessel, Airy or arbitrary beams using spatial light modulators (SLMs) in order to improve and accelerate the machining operation. Applications in micro&nano-machining by non-diffracting ultrashort laser pulses in various materials have been proposed during last decades. This will also open new perspectives for applications of complex beams for applications in microscopy, micro-electronics or ultrafast physics.

Photonic systems have also revolutionized the hardware implementation of Artificial Neural Networks and Reservoir Computing, in particular. The fundamental principles of Reservoir Computing strongly facilitate a realization in such complex analog systems. Especially delay systems, which potentially provide large numbers of degrees of freedom even in simple architectures, can efficiently be exploited for information processing. We also demonstrated learning in large-scale neural networks with numerous nonlinear nodes in an architecture using SLMs.

We will also present another area of particular importance in our research institute that concerns the developing of advanced imaging techniques for 3D motion measurement at small-scale mechatronics and automated microscopy. This work explores extended computer micro-vision capabilities offered by combining digital holographic microscopy and last generation of deep learning algorithms such as Vision Transformer networks.

In high-tech areas such as micro-robotics, micro-electronics and photonics, design and measurement requirements are increasing in terms of high resolution and their controls are based on multi-scale and complex parameters. Increasingly real-time processing remains a big challenge for future applications, where next generation of systems will need to implement new hardware architectures, maybe based on photonic neural networks.

Maxime Jacquot

CV

Maxime Jacquot received the PhD degree in engineering sciences from the University of Franche-Comté (UFC), France, in 2001. His PhD research was done in the Laboratoire d'Optique PM Duffieux (LOPMD) of Besançon and concerned digital microholography and its applications in optical metrology (interferometric holography, phase contrast imaging and microscopy). In 2002, he joined as associate professor the Laboratoire Traitement du Signal et Instrumentation (ex-LTSI, currently Laboratoire Hubert Curien) of Saint Etienne, France. His research interests dealt with spectral interferometry, optical correlator. In 2006, he joined as associate professor the Optics Department of FEMTO-ST Institute, Besançon (France). He received a Habilitation degree (HDR) in 2011 at UFC. He became full professor at UFC/UBFC in 2018. His research interests currently include nonlinear delay dynamics and its applications in optical chaos communications and photonic neural networks, digital holography and spatial laser beam shaping with SLM for surface micro- or nano-processing.

Director of the Optics Dpt, FEMTO-ST Institute since oct. 2019. Head of International Master PICS - ISITE BFC & Graduate School EIPHI since 2018. Head of "Master of Excellence for Engineering" programs since 2013 at UFC, in charge of CMI at UFC (national label (CMI-FIGURE network/ PIA IDEFI) for a Master of Excellence for Engineering and Research, with an education program designed over 5 years, in close connection with high quality research. Deputy Director of the Optics Dpt, FEMTO-ST Institute period: 2017-2019. Head of Master of Engineering PICS period: 2013-2015. Deputy Director (teaching) of the Optics Dpt, FEMTO-ST Institute, period: 2011-2016. Head of the Master PICS ('Photonics, Micro-Nano-Technologies & Time Frequency'), at UFC, period: 2008-2013.