Editorial

Photons for computing and computing for photonics

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The liaison between photonics and computing is a pillar of modern optics and subject of cutting-edge research for more than half a century. As in many scientific disciplines, high-performance computational methods have become essential for describing, designing, interpreting and ultimately predicting an optical system’s behaviour, and today the wide availability of high-performance photonic components is testimony of how computing has boosted the field of photonics. At the same time, photonic architectures offer fascinating possibilities for carrying out computations scaling beyond today’s computing hardware. This establishes an almost uniquely reciprocal relationship between photonics and computing.

The interest in photonics for computing and computing for photonics is currently exploding despite decades of research activities. As the performance of standard digital computers is levelling out, new concepts such as neural networks (NNs) or combinatorial optimization in the form of Ising and XY machines lead the way to new frontiers in information processing and are already being explored with profound commercial relevance. These evolving concepts differ significantly from conventional computing paradigms, and the quest for new, better suited types of computing hardware is accelerating with photonics offering outstanding opportunities. Simultaneously, high-performance off-the-shelf computers can now model and design increasingly complex photonic devices and systems in great detail and accuracy. These developments have created unique conditions: photonics is a promising technology for the next generation of computing hardware, and at the same time, the recent progress of digital computers has enabled design, modelling and development of a new class of photonic devices and systems with unprecedented complexities.

Many demonstrations of computing schemes based on photonic systems have by now achieved seminal status within the optics community: this includes computational Fourier optics [1], the optical Hopfield network [2], NNs [3], digital photonic computing architectures [4], as well as the emulation and minimization of Ising and XY Hamiltonians [5]. For the most part, powerful computational concepts require non-linearities, and the inverse design of such systems [6, 7] has significantly advanced thanks to adjoint methods [8]. This special issue on “photons for computing and computing for photonics” provides a snapshot of the growing reciprocal relationship between photonics and computing through review and research articles.


In conclusion, this special issue provides introductions, reviews and current research articles covering the diverse interactions between photonics and computing with a focus on photonic NNs, photonic XY and Ising machines and the utilization of NNs for the design of photonic components. We hope that this collection of articles serves as inspiration for students and young as well as established researchers. We would like to thank the Nanophotonics Publishing editor
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References


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