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Warping light into Neural Networks

In recent years, Deep Diffractive Neural Networks (D2NNs) have emerged as a powerful tool in optical computing and information processing. These systems utilise consecutive phase modulations to map a set of optical input states defined in one basis, to a new set of target states in an arbitrarily defined basis. Traditionally, the phase masks used to achieve these operations are optimised through randomly generated phase patterns or by finetuning individual pixel values using various search algorithms. In this work, we introduce a novel approach to the construction of these phase screens using Zernike polynomials. Switching from the pixel basis to this modal basis allows us to train the coefficients of the polynomials contained in each phase screen analogously to the weightings found within a traditional neural network - fewer training parameters lead to reduced computing cost and results in faster convergence during training. We demonstrate the computational abilities of this approach by characterising Laguerre Gaussian modes into predefined channels, as well as by emulating a quantum gate operation using vectors defined as a lattice of Gaussian modes. This work advances high-dimensional free-space information processing and has the potential to be adapted to real-time processing tasks.

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