Nonlinear Optical Encoding Leveraging Multiple Optical Scattering

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Optical information processing and computing promise enhanced performance, scalability, and energy efficiency, but achieving nonlinearity—a key computation component—remains challenging. We present a new design that uses a multiple-scattering cavity to passively induce optical nonlinear random mapping with a low-power continuous-wave laser. Each scattering event effectively mixes information from different areas of a spatial light modulator, creating a highly nonlinear mapping between input data and output patterns. Our design retains vital information even with reduced readout dimensionality, enabling optical data compression. This approach supports efficient optical information pre-processing across applications, including classification, image reconstruction, keypoint detection, and object detection. Notably, our design achieves high performance in real-time pedestrian detection at extreme compression ratios. These findings pave the way for novel algorithms and unconventional architectures in designs of optical processors.