

Smart snapshot full-stokes spectra-polarimetric camera enabled by optical metasurfaces and deep learning

*L. Zhang, C. Zhou, Y. Ding, H. J. Ahn, S. Chang, Y. Duan, B. Liu, X. Chen, M. T. Rahman, Z. Liu and X. Ni

Abstract: Light fields carry a wealth of information such as intensity, spectrum, and polarization. However, a standard camera captures only intensity information, disregarding other valuable data. While there are hyperspectral and polarimetric imaging systems that capture spectral and polarization information, respectively, in addition to the intensity, they are bulky, slow, and costly. Here, we have developed an all-dielectric metasurface enabling acquisition of hyperspectro-polarimetric images from a single snapshot. This metasurface, with distinct spectral and polarization responses across its building blocks, encodes spectral and polarization information into an intensity distribution that can be captured by a standard camera. This is paired with a custom deep-learning network facilitating real-time image recovery. Our experimental results demonstrate that this metasurface-enhanced camera can resolve full-Stokes polarization across a broad spectral range (700 nm to 1150 nm) from a single snapshot, achieving a spectral resolution as high as 0.23 nm. In addition, our system captures full-Stokes hyperspectro-polarimetric video in real-time at a rate of 36 frames per second, limited only by the camera's readout rate. Our metasurface offers a compact, speedy, and cost-effective solution for a multi-dimensional camera that fully utilizes information within light fields.