Researchers demonstrate high-fidelity transmission of information via novel electronic-optical system

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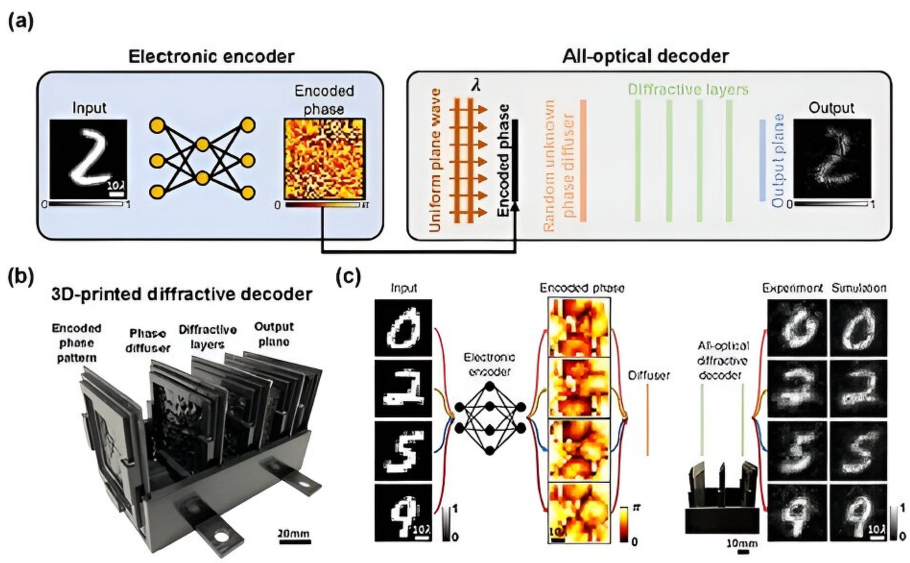

Optical information transfer through random unknown diffusers using electronic encoding and diffractive decoding. (a) The workflow of the hybrid electronic-optical model: the electronic neural network encodes the input objects into 2D phase patterns and the all-optical diffractive neural network decodes the information transmitted through random, unknown phase diffusers. (b) Photograph of the 3D-printed diffractive decoder operating at THz part of the spectrum. (c) Experimental results of optical information transfer through an unknown random phase diffuser using the 3D-printed diffractive decoder with electronic encoding. Credit: *Advanced Photonics* (2023). DOI: 10.1117/1.AP.5.4.046009

Transferring optical information in free space with large bandwidth and high transmission capacity has gained significant attention in various applications, such as remote sensing, underwater communication, and medical devices. Nevertheless, unpredictable, unknown phase perturbations or random diffusers within the optical path pose great challenges, limiting the high-fidelity transmission of optical data in free space. Adaptive optics presents a potential solution that can correct for random distortions dynamically; however, spatial light modulators and iterative feedback algorithms employed inevitably increase both cost and complexity.

A team of researchers led by Professor Aydogan Ozcan from the Electrical and Computer Engineering Department at University of California, Los Angeles (UCLA), introduced a new solution recently published in *Advanced Photonics*. This new approach uses electronic encoding and diffractive optical decoding to transmit optical information through random, unknown diffusers with high fidelity. The article is titled "Optical information transfer through random unknown diffusers using electronic encoding and diffractive decoding."

Trained through supervised learning, this hybrid model incorporates a convolutional neural network (CNN)-based electronic encoder along with co-optimized transmissive passive diffractive layers that are physically fabricated. After this one-time joint training process, the resulting hybrid model can accurately transfer optical information of interest even in the presence of unknown phase diffusers, successfully generalizing to pass information through unseen random diffusers.

This new approach significantly outperforms systems that only utilize either a diffractive optical network or an electronic neural network for optical information transfer through diffusive random media, highlighting the importance of having both an electronic encoder and a diffractive decoder that work together.

The experimental proof of concept and the feasibility of this hybrid electronic-optical model were validated using a 3D-printed diffractive network operating in the terahertz part of the electromagnetic spectrum. The optical decoder of the hybrid model can be physically scaled—either expanded or shrunk—to operate across different parts of the electromagnetic spectrum, eliminating the need for retraining its diffractive features.

The UCLA research team believes this framework would provide a low-power and compact alternative for various applications, such as the transmission of biomedical sensing and imaging data in implantable systems, underwater optical communication, and data transmission through turbulent atmospheric conditions.

More information: Yuhang Li et al, Optical information transfer through random unknown diffusers using electronic encoding and diffractive decoding, *Advanced Photonics* (2023). DOI: 10.1117/1.AP.5.4.046009

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