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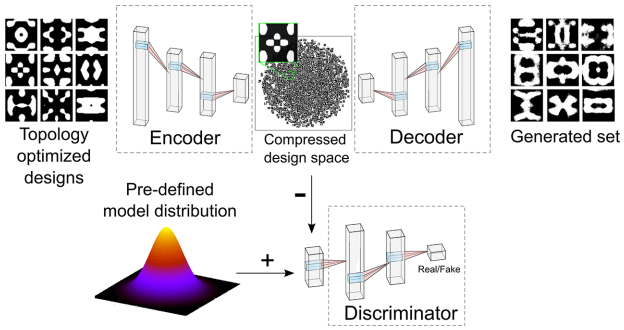
Combining machine learning with traditional nanophotonic design techniques creates device designs thousands of times faster with improved efficiencies.



Nanophotonic devices hold promise in applications ranging from energy harvesting to space exploration. However, their design is complex and nonintuitive, and since the search for the optimization of optical structures is often done by hand, it is logistically costly to comb through the large parameter space that must be considered. Using advanced optimization techniques coupled with machine learning, Kudyshev et al. developed an efficient method for nanophotonic design optimization.

“Optical design is a multifaceted optimization challenge, as any practical device should meet the stringent requirements on multi-functional performance, stability, weight, size and energy consumption,” said author Alexandra Boltasseva. “To solve such complex optimization problems, we should not rely on the intuition-based meta-structures or preexisting knowledge, but rather aim at achieving freeform, non-intuitive meta-structures.”

By coupling an adversarial autoencoder with topology optimization, the authors generated nanophotonic designs that were refined and filtered for improved efficiency.

A limitation of this method is that topology optimization is time-consuming and requires on the order of 10,000 designs to train the neural network, but only about 200 were readily available. To adequately test their method, the researchers used physics-driven data augmentation to enlarge the training set to 8,400 samples. This allowed them to train the adversarial autoencoder and develop thermal emitter metasurface designs with efficiencies up to 98% at speeds thousands of times faster than conventional optimization approaches.

“We believe that the synergy between advanced, physics-driven machine learning techniques and conventional optimization algorithms will allow complex, multi-parameter optimization frameworks to be developed,” said author Zhaxylyk Kudyshev. He hopes the technique will be applied to transform not only optical design, but also fields like electronics and biomedical synthesis.

Source: “Machine-learning-assisted metasurface design for high-efficiency thermal emitter optimization,” by Zhaxylyk A. Kudyshev, Alexander V. Kildishev, Vladimir M. Shalaev, and Alexandra Boltasseva, *Applied Physics Reviews* (2020). The article can be accessed at https://doi.org/10.1063/1.5134792.