

Deep Learning Approaches for Dispersion Engineering in Nanophotonic Devices

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This study explores the application of dispersion engineering in nanophotonic devices, focusing on the development of deep learning algorithms to predict different eigenmodes and the effective index of nanophotonic structures, thus enhancing the design process of optical devices such as achromatic metalenses, mode transformers, and nanophotonic circuits. Traditional full-wave simulation tools, while accurate, are computationally intensive, particularly in solving eigenvalues and eigenmodes. By employing deep neural networks (DNNs), we achieve a significant reduction in computational time, maintaining high accuracy in predicting the optical properties of complex structures.

Data for training these neural networks were gathered using finite element method (FEM) solvers, which includes the calculation of field distributions and eigenvalues in diverse nanophotonic configurations. The fully trained models serve as surrogate models, which are then applied to expedite the design of wideband applications. These surrogate models enable rapid prototyping and optimization of devices that require precise control over a broad spectral range.

Our designs include cylindrical lenses with tailored meta-atom structures to enhance spectral performance, covering bandwidths up to 40%. As an example, Figure 1 illustrates the electromagnetic field (E-field) distribution of an achromatic metalens designed to operate over a broad wavelength range. The image captures the lens' performance from longer wavelengths on the left side (12 μm) to shorter wavelengths on the right side (8 μm). The results demonstrate robust wideband performance, highlighting potential applications in high-resolution imaging systems and telecommunications.

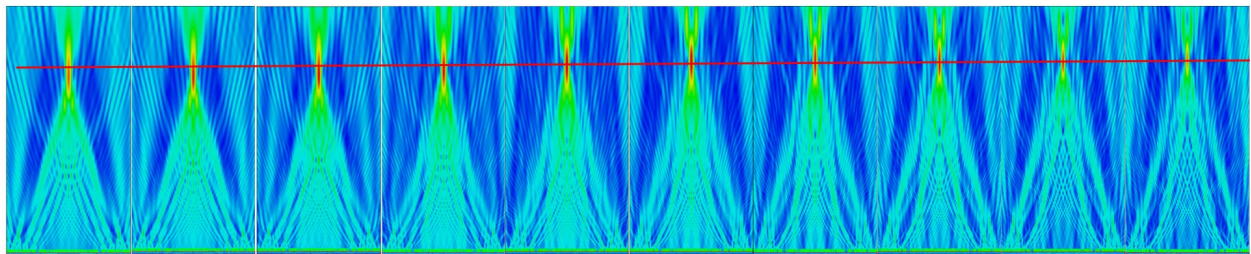


Figure 1. E-Field Distribution Across a Broadband Achromatic Metalens.