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Fast, Efficient Metamaterial Device Design via Neural Networks

Stanford researchers in the Fan Lab have developed a method that dramatically accelerates and optimizes metamaterial design with little computational resource and time using generative neural networks. The network uses known high efficiency device designs as training data to learn features, and produces device designs that mimic high performance devices. The generated devices are quickly characterized with an electromagnetics solver, and the fraction of the devices that are found to be high efficiency are kept. The network further optimizes the topology to produce even higher efficiency, robust designs. These new devices can be fed back into the neural network as additional data for training. The method is particularly suited to optimize complex, aperiodic topology designs for high performance optic devices, such as a flat lenses, gratings, and filters, and potentially electromagnetic devices, such as antennas and impedance surfaces.

Stage of Development – Prototype
The Fan Lab uses the methodology for ongoing device design and research.

Applications

- Metamaterial design for:
    - High performance **optic devices** (lens, gratings, filters) for:
        - Cameras and computer vision systems
        - Computational imaging and augmented reality
        - Microscopes and wavelength sorters for hyperspectral imaging
        - Optoelectronics (e.g. lasers, LEDs, photon sources, beam splitters, solar cells)
    - **Electromagnetic devices** (antennas and impedance surfaces)

Advantages

- Dramatically speeds up high-performance metamaterial design cycle: takes only seconds, a **10-100x reduction in time and computation resources** to produce high efficiency designs compared to using iterative topology optimization.

Publications

- Fan, Jonathan, and Jiaqi Jiang. "Systems and methods for generative models for design." US Patent Application PCT/US2019/041414. Published 2020-01-16.
- Fan, J.A., 2019, May. "Generating high performance, topologically-complex metasurfaces with neural networks." In *2019 Conference on Lasers and Electro-Optics (CLEO)* (pp. 1-2). IEEE. Doi: 10.1364/CLEO_AT.2019.AM4K.4.

Patents

- Published Application: WO2020014490
- Published Application: 20210390396

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