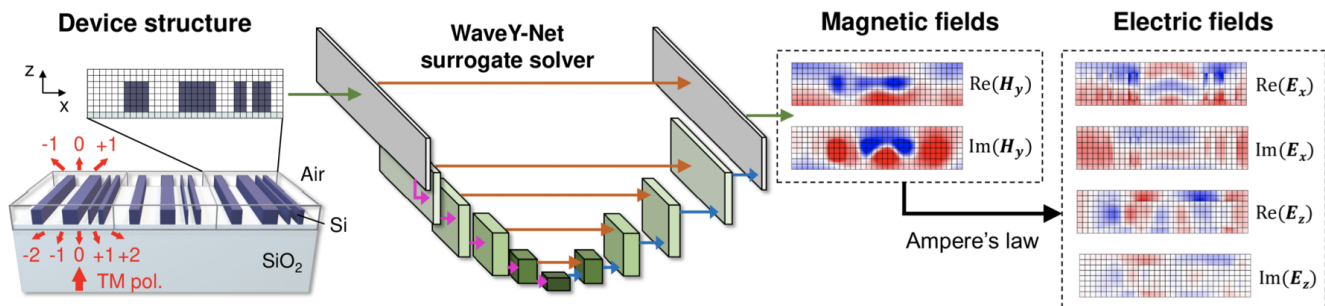


# Denoising WaveY-Net: An ultra-fast, auxiliary neural network enhanced surrogate field solver

The Fan Lab at Stanford University has developed an ultra-fast, physics-augmented, deep learning enhanced surrogate field solver for high-speed electromagnetic simulation and optimization. Denoising WaveY-Net uses a two-stage approach to target different field error sources. The conditioned surrogate solver architecture also uses a two-stage approach to generate fullwave field solutions for a given dielectric structure. The solver generates a solution for a given set of parameters, such as wavelength of illumination, angle of incident light, polarization, and material permittivity. Denoising WaveY-Net consistently optimizes topology greater than three orders-of-magnitude faster than a finite-difference frequency-domain (FDFD) solver. Adding physics into the training process qualitatively improves outcomes beyond those obtained by adding more training data. This ultra-fast and accurate field solver can save time and money for a wide range of design and modelling applications including meta-optical devices, photonics integrated circuits, RF components, additive manufacturing, and computational fluid dynamics.



(Image courtesy the Fan Lab)

**Figure 1** Schematic of a metagrating EM field evaluation with Denoising WaveY-Net. The device layout is used as the input image for the neural network, which predicts the real and imaginary part of the magnetic field  $H_y$ , which is then used to calculate the electric field components.

## Stage of Development - Prototype

## Applications

- **Meta-optical elements design** - design of high-performance and/or large-scale optical components, such as metagratings, metalens, metapolarizers, etc.
- **Photonic integrated circuits design** - used in fiber-optic communication, biomedical sensing, photonic computing, autonomous driving, etc.
- **RF component design** - commonly used for communication and imaging, such as 5G wireless telecommunications and magnetic resonance imaging.
- Freeform mechanical structure design, **additive manufacturing, 3D printing** - the Denoising WaveY-Net ultrafast surrogate solver can accelerate the iterative optimization based on adjoint-variable method used for the freeform inverse design process.
- **Computational fluid dynamics (CFD)** - Denoising WaveY-Net can bring orders of magnitude speed-up with high fidelity in simulation accuracy compared to existing CFD methods based on finite difference used for complex flow simulations, such as **aircraft aerodynamic simulations and complicated heat transfer processes** thermal analysis.

## Advantages

- **Orders of magnitude faster and much cheaper** to solve than conventional finite element method (FEM) and finite difference frequency domain (FDFD) algorithms.
- **High speed, high accuracy, and robust functionality** compared to alternative surrogate solvers based on the use of neural networks.

## Publications

- Chen, M., Lupoiu, R., Mao, C., Huang, D. H., Jiang, J., Lalanne, P., & Fan, J. A. (2022, March). [WaveY-Net: physics-augmented deep-learning for high-speed electromagnetic simulation and optimization](#). In *High Contrast Metastructures XI* (Vol. 12011, pp. 63-66). SPIE. <https://doi.org/10.1117/12.2612418>
- Chen, M., Lupoiu, R., Mao, C., Huang, D. H., Jiang, J., Lalanne, P., & Fan, J. (2021). [Physics-augmented deep learning for high-speed electromagnetic simulation and optimization](#). <https://doi.org/10.21203/rs.3.rs-807786/v1>

## Patents

- Published Application: [WO2024163664](#)

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