HAIYUN GUO

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EDUCATION

Rice University **Houston TX, USA**
PhD Program in Electrical and Computer Engineering *2021 – present*

University of Dayton **Dayton OH, USA**
M.S. in Department of Electro-Optics and Photonics *2019 – 2021*

Huazhong University of Science and Technology **Wuhan, China**
B.E. in School of Optical and Electronic Information *2016 – 2019*

RESEARCH EXPERIENCE

Rice Computational Imaging Lab **Houston TX, USA**
Ph.D. candidate under Professor Ashok Veeraraghavan *Aug 2021 – present*

Neural wavefront shaping (NeuWS): a WS technique that integrates maximum likelihood estimation, phase modulation, and neural signal representations to reconstruct high-resolution images through strong static and dynamic scattering media without guide-stars, scanning, or sparse targets.

- Design an advanced optical setup with dual 4F systems; skillfully build and assemble the setup, including lens selection, laser collimation, laser despeckle, and SLM (Spatial Light Modulator) calibration.
- Simulate the physical imaging process in **PyTorch** and implement it as the forward model.
- Conduct four sets of experiments with static/dynamic objects/aberrations; fine-tune hyperparameters and design the depth of neural networks to enhance their performance.
- Analyze the NA and resolution of the imaging system, proving our proximity to the diffraction limit.
- Publish in ***Science Advances*** in June 2023 as the first author.

Learning Wavefront Modulations (WaveMo): jointly optimize WaveMo and a computationally lightweight reconstruction network to recover scenes obscured by scattering. Our learned WaveMo can be generalized to unseen scenarios with 3.9 dB improvement and augment other unsupervised restoration algorithms.

- Design and build the optical system equipped with **SLM** and **DMD** (Digital Micromirror Device).
- Simulate the physical model in **PyTorch**, describe the distribution of anisoplanatic aberrations by Zernike polynomials, and then generate a large scattered dataset for joint training.
- Collect a human pathology dataset to fine-tune the reconstruction network; utilize **MATLAB** to control and synchronize SLM, DMD, the sensor, and the piezo stage for dynamic scattering in experiments.
- Compute the MTF (Modulation Transfer Function) to analyze the impact of learned WaveMo on frequencies.
- Submit to ***CVPR 2024*** as the first author.

FPM-INR: a compact and efficient framework that integrates physics-based models with INR (implicit neural representations) to represent and reconstruct FPM (Fourier ptychographic microscopy) image stacks.

- Propose using INR in FPM to efficiently represent high-resolution images demanding gigabytes of memory.
- Develop MLP (Multi-Layer Perceptron) networks in **PyTorch** and realize 2D reconstruction by mapping spatial coordinates to amplitude and phase with the FPM-based forward model.
- Contribute to the parameter tuning of 3D reconstruction networks and assist in its acceleration.
- Publish in ***Optica*** in Oct 2023.

Super-resolution (SR) from blur: an imaging system using pointwise-modulating programmable masks, which can physically super-resolve the resolutions by introducing a controlled blur into the optical pathway.

- End-to-end optimize a binary mask for the blurring imaging system, integrating a deep residual network (ResNet) with skip-connection to achieve better SR with fewer measurements.
- Implement masks based on block circulant matrices for a more compact system in SR video application.

Holography and Metamaterials Laboratory **Dayton OH, USA**

Graduate student under Professor Partha Banerjee *Aug 2019 – May 2021*

Single-shot Moiré patterns for 3D topography: a simple and robust technique of Moiré topography incorporating structured illumination and a digital four-step phase shifting for 3D surface mapping.

- Illuminate cosine-structured light to encode objects' depth into patterns' deformation; use Fourier processing to digitally generate four Moiré patterns with quad-phase shifting.
- Derive phase differences from four Moiré patterns, use the PUMA (Phase Unwrapping via Max Flows) algorithm in **MATLAB**, and convert phases into depths via the triangulation system formula.
- Construct a Mach–Zehnder interferometer to produce a highly dense cosine pattern, enabling experimental reconstruction of an mm-scale metallic surface with a depth resolution of tens of microns.

3D reconstruction via structured light for transparent objects

- Develop an incoherent light ray propagation model to estimate the 3D shape of transparent objects by analyzing the deformation of projected structured patterns and iteratively minimizing the MSE loss.
- Experimentally reconstruct a bi-cylinder and demonstrate its potential on arbitrary transparent objects.

Integrated Photonic Circuits Laboratory **Dayton OH, USA**

Research Assistant to Professor Imad Agha *Feb 2021 – Aug 2021*

- Simulate the heat reaction of a plasmonic light concentrator with phase change materials in **Lumerical FDTD**.
- Design a metalens with focal spots approaching the diffraction limit for a maskless lithography system.

SKILLS

Software: MATLAB (skilled), Python (skilled), Lumerical FDTD, Zemax (Optical Design), Altium Designer

Fabrication: Nanoscribe Lithography, Laser cut, 3D printing

Languages: Mandarin Chinese (native), English (fluent)

PUBLICATIONS

First-author journal papers:

- **Haiyun Guo**†, Brandon Y. Feng†, Mingyang Xie, Vivek Boominathan, Manoj K. Sharma, Ashok Veeraraghavan, and Christopher A. Metzler. *"NeuWS: Neural wavefront shaping for guidestar-free imaging through static and dynamic scattering media."* Science Advances, (2023).
- **Haiyun Guo**, Haowen Zhou, and Partha P. Banerjee. *"Use of structured light in 3D reconstruction of transparent objects."* Applied Optics, (2022). ***−− Editor's Pick Reward***
- **Haiyun Guo**, Haowen Zhou, and Partha P. Banerjee. *"Single-shot digital phase-shifting Moiré patterns for 3D topography."* Applied Optics, (2021).

Journal papers:

- Haowen Zhou†, Brandon Y. Feng†, **Haiyun Guo**, Siyu (Steven) Lin, Mingshu Liang, Christopher A. Metzler, and Changhuei Yang. *"FPM-INR: Fourier ptychographic microscopy image stack reconstruction using implicit neural representations."* Optica, (2023).
- Haowen Zhou, **Haiyun Guo**, and Partha P. Banerjee. *"Non-recursive transport of intensity phase retrieval with the transport of phase."* Applied Optics, (2022).
- Gary A. Sevison, Joshua A. Burrow, **Haiyun Guo**, Andrew Sarangan, Joshua R. Hendrickson, and Imad Agha. *"Wavelength and power dependence on multilevel behavior of phase change materials."* AIP Advances, (2021).

Conference papers:

- **Haiyun Guo**†, Brandon Y. Feng†, et al. *"NeuWS: Neural Wavefront Shaping for Guidestar-Free Imaging Through Static and Dynamic Scattering Media"* Asilomar Conference on Signals, Systems, and Computers. IEEE. (2023).
- Brandon Y. Feng†, **Haiyun Guo**†, et al. *"Neural Wavefront Shaping in the Photon-Starved Regime."* Optica Imaging Congress COSI. (2023).
- Shiqi Luo, Kaitrin Weber, **Haiyun Guo**, Wenqi Zhu, Amit Agrawal, and Imad Agha, *"A Maskless Lithography System Based on Digital Micromirror Devices (DMD) and Metalens Arrays."* CLEO: Applications and Technology. Optica Publishing Group. (2023)
- **Haiyun Guo**, Haowen Zhou, and Partha P. Banerjee. *"Surface shape reconstruction of transparent objects using structured light."* In Digital Holography and 3D Imaging. Optica Publishing Group. (2021).
- Mallik M. R. Hussain, **Haiyun Guo**, and Partha P. Banerjee. *"Ptychographic coherent diffractive imaging, digital holography and structured light techniques for topographical 3D imaging."* In Pattern Recognition and Tracking XXXII. SPIE. (2021).
- **Haiyun Guo**, Haowen Zhou, and Partha P. Banerjee. *"Single-shot digital phase-shifting Moiré pattern for 3D metallic surface imaging."* In Digital Holography and 3D Imaging. Optica Publishing Group. (2020).