Machine-learning Driven Inverse Design of Optical Metasurfaces

About AFRL:

Air Force Research Laboratory (AFRL) is a scientific research organization operated by the United States Air Force Materiel Command. AFRL is dedicated to leading the discovery, development, and integration of aerospace warfighting technologies, planning, and executing the Air Force science and technology program, and providing warfighting capabilities to United States air, space, and cyberspace forces.

RESEARCH LOCATION: Wright-Patterson AFB, OH

PROJECT DESCRIPTION:

The Accelerated Materials exPloration and Discovery (AMPD) research group utilizes machine learning, scientific computing, and data analytics to accelerate the development of the next generation of structured optical materials as well as support the development of functional materials. AMPD is a part of the Structured Optical Materials Processing Research Team in the Photonic Materials Branch of the Materials & Manufacturing Directorate.

Artificial neural networks may be physically realized as cascaded optical metasurfaces, providing a method for passive manipulation of light-based information, simultaneously improving the C-SWAP and efficiency of a system. The goal of this internship is to investigate the design of these multifunctional deep diffractive neural networks and characterize their computing performance.

The intern will investigate DDNNs with existing tools while learning how to design for multifunctionality and robustness. The internship will consist of 1) designing DDNNs capable of multiple computational tasks, for example as a coronagraph and as wavefront sensor, 2) simplifying designs to combine functionalities, and 3) and refining designs to make them resistant to fabrication error by leveraging existing databases of optical metasurface elements (“meta-atoms”). Research will include set up of simulation and design routines, analysis of simulated performance, the use and development of machine learning models to predict optimal optical meta-elements and developing metrics to compare multifunctional performance of different metasurface designs.

Weeks 1-2: Introduction to AFRL/RX, AMPD Research Group, DSRC, Python, (DNA)2, and MANTIS

Weeks 3-4: Exploration of DDNN designs for single functionality

Weeks 5-6: Augmentation of DDNN designs to achieve multifunctionality

Weeks 6-8: Design of DDNN resistant to fabrication error

Weeks 9-10: Prepare final report, presentations (HIP presentation, poster to AFRL/RX, etc.)

The intern will gain familiarity and experience with 1) the theory and design of optical metasurfaces including deep diffractive neural networks, 2) training of machine learning models, specifically artificial neural networks, and 3) scientific computing, high-performance computing, and cloud computing, including computational electromagnetics simulations and data analysis. Skills acquired by the intern will be transferrable to nearly any scientific or engineering discipline as scientific computing, data analysis, and machine learning are gaining broad adoption. These skills will be developed by working with our codes and workflows on our local computing cluster, virtual machines on the Google Cloud Platform, and running simulations on the HPC. This internship provides a rich research experience, providing the intern concrete research opportunities while allowing the intern to pose and answer their own research questions.

The Materials & Manufacturing Directorate at AFRL (AFRL/RX) provides many enrichment opportunities for interns to learn more about STEM research and career pathways. These include the weekly "RX 101" seminar series providing an overview of the research teams across the directorate as well as various technical seminars highlighting research conducted at the lab and by collaborators at universities and/or other national laboratories. The intern will also be able to interact with other summer interns at AFRL/RX, will have opportunities to talk with postdocs and research scientists in one-on-one or small group settings to learn more about their career path and current research, and will be encouraged to present at the summer student poster session, providing an opportunity to discuss their research with scientists from across the entirety of AFRL.

ANTICIPATED START DATE:

May 2025 – Exact start dates will be determined at the time of selection and in coordination with the selected candidate.

QUALIFICATIONS:

The ideal candidate should be currently pursuing a technical degree in science or engineering e.g. Physics, Materials Science, Optics, etc. Course work or experience in optics is not required. Previous experience with UNIX-like operating systems i.e. Linux is highly encouraged, as is coding experience in any language, with Python experience preferred.

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Bachelor's
- Master's
- Doctoral

DISCIPLINE NEEDED:

- Chemistry and Materials Sciences
- Physics
- Engineering
- Science & Engineering-related