Predicting the Thermoelastic Response of Gradient Composition Infrared Windows

About DEVCOM ARL:

The DEVCOM Army Research Laboratory (ARL) is designed to significantly increase the involvement of creative and highly trained scientists and engineers from academia and industry in scientific and technical areas of interest and relevance to the Army. Scientists and engineers at ARL help shape and execute the Army's program for meeting the challenge of developing technologies that will support Army forces in meeting future operational needs by pursuing scientific research and technological developments in diverse research fields.

RESEARCH LOCATION: Aberdeen Proving Ground, MD

PROJECT DESCRIPTION:

This project seeks to understand the influence of gradient composition in the deformation of infrared (IR) windows when subjected to extreme environments. To optimize sensor performance (e.g., accuracy when tracking a target), targeting error must be minimized. However, when operating in extreme conditions, IR windows can undergo bowing due to thermal gradients as one side of the material expands more than the other. This results in refraction of incoming light, thus reducing the accuracy of target tracking. While accounting for the expected deformation can help performance, ideally, we want to deploy systems that integrate material solutions that are able to minimize the deformation. Additive manufacturing techniques allow for the creation of gradient compositions across and through the window to reduce deformation, but specific designs will be material and environment specific.

This project seeks to understand the influence of rate of gradation and boundary conditions (thermal environment, edge cooling, constraints) on the thermoelastic response of infrared windows exposed to extreme environments. A finite elements code will be used to model the evolution of the temperature, stress, and deformation of potential materials. HPC resources will be utilized for creating FEniCS meshes for gradient designs and perform coupled thermomechanical simulations. The intern will develop workflows to automate this process and then use them to explore the designs space. Further, the finite elements model will need to be refined to better capture the relevant heat transfer conditions.

The Army Research Laboratory has an active intern program that includes tours of several individual laboratories at locations in Aberdeen Proving Ground and Adelphi, MD. Throughout the summer, there are planned functions/socials at the team, branch, and division level to interact. Furthermore, there are frequent programs, team, and branch meetings to help introduce interns to the culture at ARL.

Throughout the summer, the intern will receive hands-on training on using the DSRC systems, running simulations, and analyzing simulation data. Linux workstations will be used to train the intern on accessing DSRC resources and transferring data to/from the clusters. The intern will be provided with extensive training on fitting machine learning models and running parallelized software (e.g., FEniCS). Additionally, the intern will be trained in using post-processing tools for studying the simulation results (e.g., Paraview).

There are multiple opportunities to network with other interns, postdoctoral associates, and ARL S&Es. The mentor will seek to facilitate individual meetings between the intern and specific staff members whose research portfolio or professional experience best aligns with the intern's intended professional path. Additionally, the intern will have the opportunity to interact with human resources and learn more about careers in the government defense laboratories.

The proposed research plan is flexible enough to fit the experience of the interns, so specific expectations of technical activities will be adjusted accordingly.

ANTICIPATED START DATE:

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

QUALIFICATIONS:

Graduate students with interest in materials modeling.

Preferred skills:

- Python or C/C++
- Basic/moderate understanding of parallel computing
- Understanding of finite element models
- Knowledge of numerical methods, machine learning, or design optimization

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Master's
- Doctoral

DISCIPLINE NEEDED:

- Computer, Information, and Data Science
- Engineering