DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING
COLLEGE OF ENGINEERING AND APPLIED SCIENCE

RESEARCH OPPORTUNITIES FOR UNDERGRADUATE students

APPLICATION DEADLINE: September 22, 2025

PROJECT TITLE: Stochastic bilevel optimization and its applications to neural architecture search

Physical Requirement :
None

Project's Technical Skills Requirement :
Preferred skills: Background in mathematical optimization and algorithms, Programming experience in Python, Familiarity with neural networks, Curiosity about machine learning and AI

Project's Available Positions : 1

Tommaso Giovannelli
Department of Mechanical and Materials Engineering
College of Engineering and Applied Sciences
635 Rhodes Hall
Cincinnati, OH 45221
giovanto@ucmail.uc.edu
Phone: 513-556-6926

Project Description

Many important decisions in engineering, computer science, and artificial intelligence involve two levels of decision-making. For example, a company may first decide on the design of a product (upper level) and then determine how best to produce it (lower level). This type of problem is called a bilevel optimization problem. In our research, we are particularly interested in situations where some decisions must be made from a set of discrete options (e.g., "yes or no," or choosing between a small number of possibilities), while others are more continuous (e.g., adjusting a parameter across a range of values). Problems that mix both types of decisions are especially challenging and are at the core of many modern applications. One exciting application is neural architecture search, which is about automatically designing the structure of neural networks rather than relying only on human intuition. Optimizing these architectures can lead to better-performing AI systems for tasks such as image recognition, natural language processing, and medical data analysis.

The goal of this project is to design, analyze, implement, and test a new

algorithm that can handle these challenging problems efficiently. The algorithm will alternate between exploring continuous decision variables (leveraging derivative information) and discrete decision variables (where we use randomized strategies to make progress). By combining these approaches, we aim to develop methods that are both effective and scalable to problems with many decision variables.

This project will be completed in the Operations Research and Data Science Lab in the Department of Mechanical and Materials Engineering. You will be part of a team working at the intersection of optimization, data science, and artificial intelligence.

Preferred skills include:
- Background in mathematical optimization and algorithms
- Programming experience in Python
- Familiarity with neural networks
- Curiosity about machine learning and AI

Training provided:
- Introduction to bilevel optimization and neural architecture search
- Training in Python optimization libraries (e.g., PyTorch) and coding practices
- Training in scientific writing
- Opportunities for research presentations at local and national levels