



Regional Introduction to Plasma Processes



Project Title: Hyperparameter Optimization Procedures in Physics-Informed Machine Learning and Plasma Physics Applications

Project Reference Code: Schoenbaum-UAH

Name of Project Leader: Lucius Schoenbaum

Host Facility: University of Alabama in Huntsville

Internship Location: CSPAR, Cramer Research Hall, UAH

Host Facility Location: 320 Sparkman Drive, Huntsville, AL 35899

Project Description:

The student/mentee will perform a qualitative and quantitative comparison of the performance of hyperparameter optimization using Gaussian Processes with hyperparameter optimization using a straightforward Grid Search. The underlying machine learning task will be a physics-informed neural network modeling of a PDE problem originating in classical/semiclassical kinetic modeling or radiation transport theory. Example code and guidance/supervision will be provided by the mentor.

Disciplines: Physics-Informed Neural Networks, Kinetic Modeling, Physics-Informed Machine Learning

Importance: The importance of machine learning in physical sciences is growing rapidly. Hyperparameter optimization, a mature subdiscipline of machine learning, is motivated by the complexity of machine learning optimization (training) of medium-to-large scale models, which is subject to hyperparameters (inputs of floating point, or integer type) that are too numerous to set optimally by hand. Hyperparameters determine the final form of the training procedure after the logic of the training algorithm has been fixed. Changes in these hyperparameters can result in direct effects on output accuracy, as well as significant effects on the training overhead. The goal of hyperparameter optimization is to set hyperparameters algorithmically. A range of general-purpose approaches to hyperparameter optimization, in addition to methods specific to physics-informed neural networks (PINNs), have been studied in the literature.

Requirements:

- **Preferred Major:**
 - Physics, Computer Science, Mathematics, or a related field
- **Class work:**
 - Background in machine learning at introductory textbook level, background/coursework on introductory differential equations, linear algebra, statistics
- **Programming knowledge:**
 - Numerical programming in Python, experience using numerical simulations for physical modeling applications
- **Software knowledge:**
 - Python, Python Standard Library, Numpy, Scikit-Learn
- **Other:**
 - Interest and curiosity in physics and machine learning



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Biography:

Lucius Schoenbaum is studying machine-learning applications in plasma physics, particularly physics-informed networks, at CSPAR. He earned his PhD in mathematics at Louisiana State University (LSU). He subsequently joined the CSPAR research institute as a postdoctoral researcher.

Is U.S. citizenship required to participate in this project? No

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Name(s) of Mentor(s) and contact information: Lucius Schoenbaum (lts0016@uah.edu)

Internship Coordinator/ HR manager: Laura Provenzani, lp0020@uah.edu