Project for Team 3

Project Title: Space Environment Modeling and Uncertainty Quantification with Deep Neural Networks

Objective: To design efficient deep neural networks for space environment modeling and uncertainty quantification in space environment / lunar exploration *applications* and optimize their performance and efficiency.

Description: Space environment, particularly, the electric potential profiles near the surface of the Moon, is vital for lunar surface exploration. The electric potential will drive the dynamics of charged dust grains at local scales which may significantly affect the operations of instruments and astronauts for lunar surface missions. For this DL-GPU workshop, students in Team 3 will undertake a project to design a suitable deep neural work model for predicting space environment and dust levitation near the lunar surface and optimize its performance and efficiency. The project will be divided into three key stages:

1) Model Design and Exploration: The first stage requires students to investigate the best-fit models for calculating the 1-D electric potential profile above the lunar surface, for which the physics-based model is described by a 1-D ODE with a few variables as parameters in the ODE. In particular, the students will explore the use of multiple models including Multilayer perceptron, Convolutional Neural Network, Residual Network, and Recurrent Neural network.

2) Model Optimization with Neural Architecture Search (NAS): Subsequently, students will optimize the quality and/or efficiency of these models using NAS. The search will be constraint to the use of single A100 GPU with 40 GB memory. The students will also explore the use of pruning techniques to improve the efficiency of models if there is available time.

3) Resource Usage and Computational Cost Analysis: In the final stage, students will evaluate the quality of different optimized models on the target application and their performance using Nsight Systems/Compute. They will compare accuracy, memory usage, computational cost, and other performance metrics and draw a conclusion regarding the trade-offs among them.

Expected Outcome: Students will understand how to design, optimize, and implement deep learning models targeting a specific platform. They will learn how to balance accuracy and efficiency, which is crucial in real-world applications like geographical feature detection. Also, they will have a deep insight into the resource consumption of different models.