Project for Team 4

Title

Deep-Learning Model for Optimization of an Electrostatic Sieve for Lunar Regolith Beneficiation

Objective

To develop a model that optimizes the yield of an electrostatic sieve that separates lunar soil particles by size by finding a relationship between the yield and the input parameters of the sieve.

Description

This research project is focused on modeling a system for separating lunar soil particles by size. In this case, a parallel array of electrodes is used to generate an electrostatic traveling wave by switching the phase of the potentials on the electrodes after a period. The balance between the electric field generated by the electrode array and the weight of the lunar particles is used to separate the lunar particles by size and the lighter lunar soil particles are collected at the base of the electrode array. This system is referred to as the electrostatic sieve in this project, and the yield of the sieve is calculated by dividing the weight of the collected lunar soil particles below the desired radius by the weight of the fed lunar soil particles below the desired radius.

We propose to develop different predictive models to estimate the yield of an electrostatic sieve. In particular, the models will take into account key input parameters such as electrode potential, sieve inclination angle, electrostatic wave frequency, number of phases, number of electrodes, etc. To create a comprehensive and granular dataset, we will first define a realistic range for each input parameter. The dataset will then be divided into three parts (8:1:1) train, validation, and test sets. This will help us understand the model's performance on seen and unseen data. The dataset will be used to train and validate traditional machine learning methods such as regressors and deep learning methods such as transformers. We anticipate that the high-dimensional input handling capability of the latter will be advantageous for this task. Time permitting, we will also explore the use of attention layers and physics-informed loss functions to potentially enhance model performance. To provide researchers insights and guidance on hardware preparation, these methods will be implemented and evaluated using both CPUs and GPUs with a comprehensive comparison of performance and efficiency. Given the computational constraints of the existing data generation process, we expect our deep learning models to significantly accelerate the process of yield prediction. This should streamline the identification of optimal input parameter combinations, ultimately saving valuable time for researchers.

Tasks/Milestones

1) Define range for each input parameter
2) Generate the dataset
3) Develop and evaluate traditional machine learning models

4) Develop, evaluate, and optimize deep learning models
5) Compare the performance and efficiency of CPU- and GPU-based implementations Expected Outcome: Students will learn how to design and train machine/deep learning models for real applications and understand the performance and efficiency of CPU- and GPU-based implementations.

Project Presentation: 30-minute team presentation on Friday, June 7th, 2024

Paper Draft: a 10-page paper using the new ACM proceedings templates at https://www.acm.org/publications/proceedings-template . For Latex users, version 2.07 (last update April 18, 2024) is the latest template, and please use the "sigconf" option.