Name: Katie Edwards

Mentors: Dr. Jane Nachtman(UI), Dr. Hongyang Gao(ISU), Dr. Jin Tian(ISU)

Project Name: Geometric Machine Learning with DUNE

Project Overview

Geometric machine learning aims to improve the way that algorithms view and recognize a variety of objects in 3D space using the different geometric relationships within data. This project will focus on analyzing and improving the mathematical algorithms behind the interpretation of data from machine learning experiments. More specifically, in this project, I will utilize geometric machine learning algorithms to analyze data from neutrino experiments, namely from the DUNE project. One of my mentors, Jane Nachtman, has worked with Fermilab on the DUNE experiment, which is what brought the project in this direction. With many of these neutrino experiments, the data that is received is difficult to interpret and must be reconstructed in an easier-to-understand way so it can be useful. In the past, The DUNE Collaboration has used convolutional neural network(CNN) reconstruction to reconstruct tracks and showers in the ProtoDUNE detector. Another facet of my project is to compare my finalized results using geometric machine learning with the results from the CNN reconstruction to determine the strengths and weaknesses of both methods. To maximize the productivity of this project, I will be collaborating with students from the University of Iowa who will also be working with DUNE reconstruction algorithms and can help to interpret the results.

Objectives

Throughout the duration of this project, my main goal is to improve tracking algorithms used in geometric machine learning experiments for the DUNE project. In addition, I will compare the DUNE results found from geometric machine learning and compare them with results using CNN reconstruction. At the end of this project, I will deliver a final presentation and report of the work that I completed over the duration of the fellowship.

Timeline

Period: 12 weeks

Hours per week: 40

Start Date: 16 May, 2022

Completion Date: 5 August 2022

- Weeks 1-2: Focus on learning by familiarizing with the platform and data
- Weeks 3-4: Identify aspects of an algorithm to improve
- Weeks 5-6: Work on improving the algorithm
- Weeks 7-8: Continue algorithm improvements
- Weeks 9-10: Organize overall findings and use CNN reconstruction to compare with machine learning-acquired DUNE results
- Weeks 11-12: Deliver final presentation and report

Referenced Articles

Fermilab. (n.d.). *DUNE*. Deep Underground Neutrino Experiment. https://www.dunescience.org/.

Ju, Xiangyang, et al. "Performance of a Geometric Deep Learning Pipeline for HL-LHC Particle Tracking." *The European Physical Journal C*, vol. 81, no. 10, Oct. 2021, p. 876. *Springer Link*, https://doi.org/10.1140/epjc/s10052-021-09675-8.

Psihas, Fernanda, et al. "A Review on Machine Learning for Neutrino Experiments." *International Journal of Modern Physics A*, vol. 35, no. 33, 2020, p. 2043005., https://doi.org/10.1142/s0217751x20430058.

The Dune Collaboration. *Separation of Track– and Shower–like Energy Deposits in ProtoDUNE-SP Using a Convolutional Neural Network*. 31 Mar. 2022.