Spring Data Clinic 2024: Fermilab Graph Neural Network
Hierarchical 'Sawtooth' Implementation

Neutrinos, abundant yet elusive particles due to weak interactions, are a key physics research focus. Fermilab is developing a Graph Neural Network (GNN) model, using data from a 'Liquid Argon Time Projection Chamber' (LArTPC), to distinguish neutrinos and predict their paths. This enhances neutrino detection, aiding research and future experimental applications.

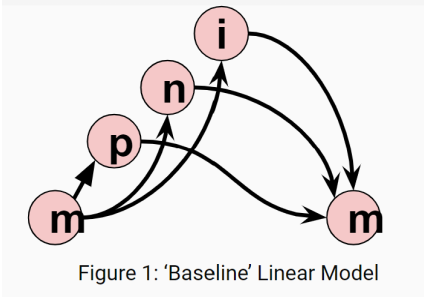

Figure 1: 'Baseline' Linear Model

This team transitioned Fermilab's baseline linear model to a hierarchical one. The original model used low-level graph nodes to represent detector hits, generating binary filtering scores and semantic labels for each hit. These were aggregated into a graph-level representation(event embedding) to infer neutrino interaction coordinates. This process was suboptimal due to repetitive aggregation operations and the lack of message passing at the graph level to iteratively improve the event embedding.

The team addressed the shortcomings of the baseline model by implementing and optimizing a hierarchical model using the 'sawtooth' architecture (figure 2). This approach leveraged message passing at multiple levels to produce better node and event-level embeddings while avoiding repetitive operations. As a result, we achieved similar performance metrics with significantly reduced resource overhead (figure 3).

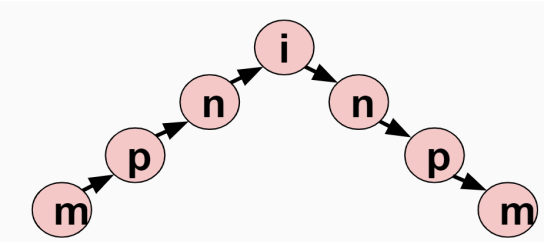

Figure 2: Hierarchical 'Sawtooth' Model

Figure 3: Comparison of model performance and compute overhead