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Graph Neural Network for Object Reconstruction in Liquid Argon Time Projection Chambers

The Exa.TrkX project presents a graph neural network (GNN) technique for low-level reconstruction of neutrino interactions in a Liquid Argon Time Projection Chamber (LArTPC). GNNs are still a relatively novel technique, and have shown great promise for similar reconstruction tasks in the LHC. Graphs describing particle interactions are formed by treating each detector hit as a node, with edges describing the relationships between hits. We utilise a multihead attention message passing network which performs graph convolutions in order to label each node with a particle type.

We present an updated variant of our GNN architecture, with several improvements. After testing the model on more realistic simulation with regions of unresponsive wires, the target was modified from edge classification to node classification in order to increase robustness. This change simplifies the model and renders its output more easily interpretable without sacrificing model performance. Removing edges as a classification target also opens up a broader possibility space for edge-forming techniques; we explore the model's performance across a variety of approaches, such as Delaunay triangulation, kNN, and radius-based methods.

While the previous version of our GNN architecture classified detector views independently, the updated variant also utilises 3D context information to share information between views. By using reconstructed 3D spacepoints to map detector hits from each wire plane, the model natively constructs 2D representations that are independent yet fully consistent.

Significance

We present for the first time several major developments to our graph neural network model. Network output has been entirely overhauled, and we present a novel mechanism for using 3D graph nodes as a nexus for information flow between detector views, enforcing classification of 2D nodes to be fully consistent between detector views.

References

Neutrino Physics and Machine Learning workshop 2020 https://indico.slac.stanford.edu/event/371/timetable/#36-graph-neural-networks-for-r
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