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NuGraph3: Towards Full LArTPC Reconstruction using GNNs

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The highly detailed images produced by liquid argon time projection chamber (LArTPC) technology hold the promise of an unprecedented window into neutrino interactions; however, traditional reconstruction techniques struggle to efficiently use all available information. This is especially true for complicated interactions produced by tau neutrinos, which are typically large, consist of many tracks, and differ from other interactions largely by subtle angular differences.

NuGraph2, the Exa.TrkX Graph Neural Network (GNN) for reconstruction of LArTPC data is a message-passing attention network over a heterogeneous graph structure, with separate subgraphs of 2D nodes (hits in each plane) connected across planes via 3D nodes (space points). The model provides a consistent description of the neutrino interaction across all planes. The GNN performed a semantic segmentation task, classifying detector hits according to the particle type that produced them, achieving ~95% accuracy when integrated over all particle classes.

Based on this success, we are building a new network, NuGraph3, which will generalize NuGraph2's structure to a hierarchical message-passing attention network. The lowest layer will consist of the same subgraphs of 2D nodes that NuGraph2 operates on. Higher layers will be dynamically generated through a learned metric space embedding. This will allow the network to build higher level representations out of low level hits. After iterative refinement, the hierarchical structure will reflect a particle tree reconstruction of each event. This hierarchical structure also provides a natural way to construct event level features for use in reconstructing quantities like vertex position and neutrino interaction classification. We will present preliminary work building particle clusters, and compare semantic segmentation results with and without hierarchical message passing.

Poster prize

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