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Predicting Missing Regions in Charged Particle Tracks Using a Sparse 3D Convolutional Neural Network

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The 2x2 Demonstrator is a prototype detector for the Deep Underground Neutrino Experiment (DUNE)'s Near Detector. Both the 2x2 Demonstrator and the Near Detector itself will have inactive regions wherein there is no sensitivity to charge deposition and light signals that arise from charged particle interactions with liquid argon. In the 2x2, these inactive regions are positioned in-between the active detector modules, which introduces the challenge of inferring what charge signals ought to look like in these regions.

This study explores the use of a Sparse 3D Convolutional Neural Network (ConvNet) to infer missing regions in charged particle tracks. Hits corresponding to energy depositions are voxelized into a three-dimensional (3D) grid for each track. Inactive regions within the tracks are replaced with a dense, rectangular 3D grid of voxels, ensuring consistent step sizes in X, Y, and Z directions. Voxels in these dense regions are initialized with an energy value of -1, indicating nonphysical energy or charge. The model is trained to predict which voxels should activate as part of the track and which should not, with the goal of eventually inferring the missing charge or energy values in these voxels. Results indicate that the model accurately predicts track voxels within ±1 unit in X, Y, or Z directions and effectively identifies non-track voxels, despite some overprediction. The approach shows promise in prediction of missing track regions with some accuracy.

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