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Fermi-Tag Team One Pager

Neutrinos are uncharged subatomic particles that are difficult to detect and poorly understood. While neutrinos are fundamental particles in the standard model of particle physics, many of their properties remain unknown. Studying neutrinos provides scientists with an opportunity to improve the current model of physics and potentially develop new research areas. Fermilab, through the MicroBooNE experiment, studies neutrinos using a highly sensitive neutrino detector. While sensitive enough to measure events that contain neutrino interactions (or "neutrino events"), the detector also records non-neutrino events such as cosmic rays and other particles (or "noise"). Figure 1 below displays an example of a neutrino event image. Currently, Fermilab stores all event data. Ideally, scientists would be able to filter event data in real time to save data for neutrino interactions and ignore all event data for cosmic rays.

The Fermi-Tag project is developing Convolutional Neural Network (CNN) models to classify detector events in real time as containing neutrinos or not. Existing classification models for neutrino events use images reconstructed from the raw data where the reconstruction takes around 5 minutes per image. This slow reconstruction process is incompatible with real time classification. This project provided models that can classify events quickly directly from raw data with minimal data preprocessing, making it ideal for real-time settings. As a result, classification can occur simultaneously with data collection to drop noise data which can improve data storage efficiency.

The Fermi-Tag team successfully created and ran CNN models for classifying neutrino events using simulated raw detector data rather than reconstructed image data (Figure 2 below displays the confusion matrix output for the CNN model test). For the next step, the team has identified several areas of potential improvement. The first is to improve the downsampling process of the large raw detector image to limit image size while preserving physically relevant information. The second is to train the model on a much larger dataset as more simulated data become available from Fermilab. The team is also working on a sparse CNN model that exploits the sparsity of the data structure to improve training and prediction time.

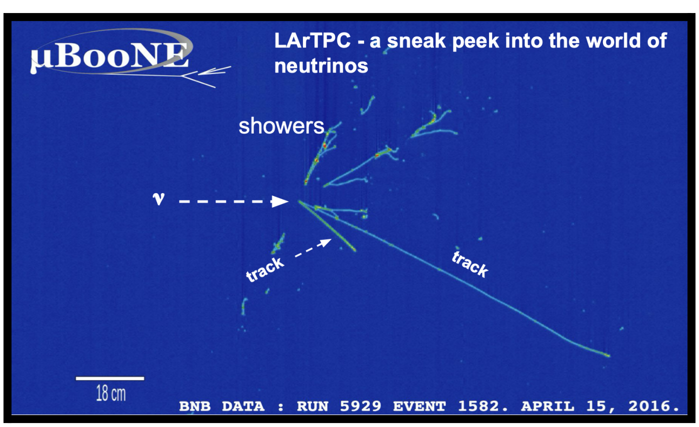

Figure 1: An event with neutrino interactions from Fermilab detectors

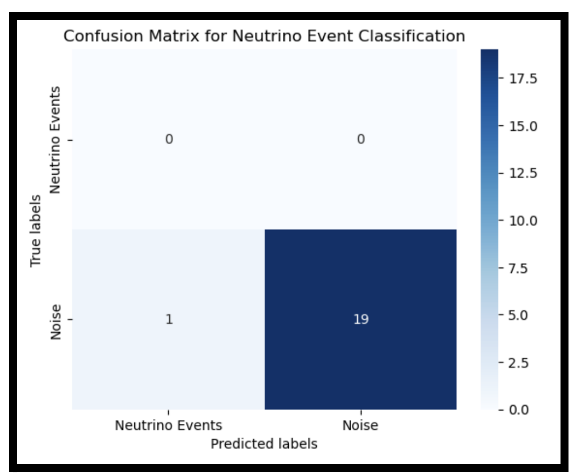

Figure 2: Confusion matrix with the CNN's results