Big Liquid Argon detector to observe neutrinos produced by FERMILAB and sent to South Dakota

Designed to precisely measure (anti)neutrino oscillations and measure matter/anti-matter differences

Sensitivity to rare events, e.g., close-by Supernovae explosion, proton decay
What is DUNE

- 1500 m underground
- 4 modules, each consisting of 10 kton LAr
- can observe charged particles produced by neutrinos (or by noise)
- Unlike LHC: no vertex interaction point: the interaction can happen anywhere (and anytime, e.g., for supernovae)
- Observe XY and XZ 2D views. Needs to reconstruct the 3D image
First application of Deep Learning to particle physics was a neutrino reconstruction problem.

Successfully demonstrated power of computing vision techniques for our problems.

Problem scale smaller than what we want to face.

Smaller detector.

NN applied locally to region already identified by classic algorithms.

Such an offline approach is under study for DUNE as well (not the topic of this project).
All problems track down to the fact that neutrinos don’t like to interact with other particles. So one needs A BIG DETECTOR and a LOT OF NEUTRINOS to make sure that a decent amount will be seen.

Due to this

- Very high data rates (up to 4.6 TB/s!)
- Limited bandwidth cannot be handled using large-energy thresholds, since rare events (e.g., supernova neutrinos) come at low energy.
- Real physics events are very rare, and the majority of the readout for each of these rare events is mostly noise.
- The noise outweighs the real physics in data size by a factor $10^7$.
- Internal background events from $^{39}$Ar decay: 1 event/second/1
- Need to filter noise, apply zero-suppression and have region of interest selection to reduce the data rate and allow for trigger-less data taking.

Built on repeated structure

Total: 150 readout planes/module
2560 readout channels/plane
384000 channels/module
ProtoDUNE

“Small scale” prototype built and operated at CERN
This partnership with MICRON aims to integrate deep learning solution in the real-time data acquisition process of the experiment.

Two use cases identified:

- **Step1:** design a local-noise suppression algorithm that could reduce the event size and reduce throughput.
- **Step2:** design a by-module (or global?) event classifier capable of rejecting the obvious background and free some bandwidth.

Each step will consist of:

- Designing the ML model.
- Integrate it on MICRON hardware.
- (Eventually) produce a demonstrator on simulation or ProtoDUNE data.
An example: Noise Suppression

Example taken from MicroBooNE (smaller scale neutrino experiment operated @FNAL)
An example: Noise Suppression

- We already solved a similar problem for LHC events (pileup suppression)
- take a single hit
- look nearby & build a near-neighbours graph
- process the graph with Message-passing NN, classifying good vs noise events
- Works very well there, should also work here