FERMILAB-SLIDES-24-0205-STUDENT

Machine Learning for DUNE Supernova Trigger

Stephanie Damish, Dartmouth College – SULI Program I Meghna Bhattacharya, Fermilab

Introduction & DUNE Background

- DUNE will consist of the world's most intense neutrino beam, which will be located at Fermilab, as well as two detectors: a near detector (at Fermilab) and a far detector (at SURF, South Dakota)
- DUNE will use Liquid Argon Time Projection Chambers (LArTPCs) to detect neutrino interactions
- In LArTPCs, particle interactions ionize the LAr medium. An electric field is applied between the plates such that the ionization electrons drift towards the collection plane
- One of the major scientific goals of DUNE is to detect and measure the neutrino flux from galactic core-collapse supernovae

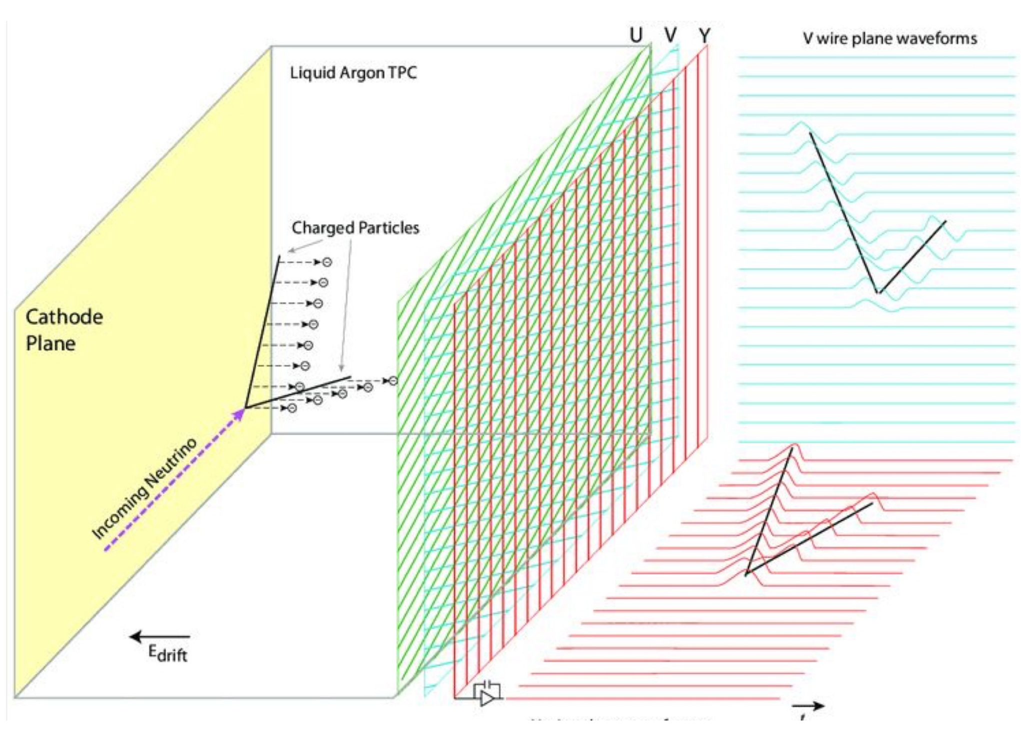
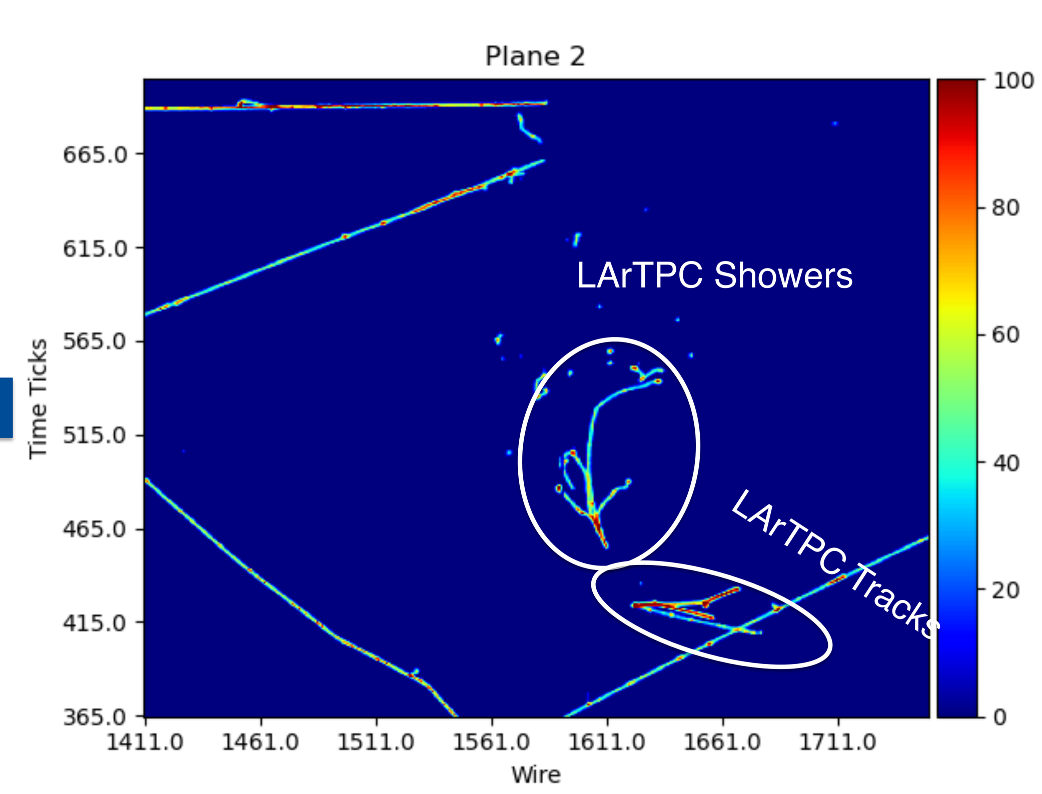


Fig 1: Diagram of LArTPC technology, which will be used by DUNE's far detector to provide precision tracking and calorimetry.

Detecting Supernova Neutrinos

- 99% of the gravitational binding energy of core-collapse supernovae is carried away by neutrinos
- Galactic supernovae are expected to occur once every few decades. Neutrinos from a core-collapse supernova have been observed once before, with SN 1987a
- DUNE detectors require a **trigger** to signal when supernova neutrino events occur
- Goal of this work is to build the **machine learning pipeline** that will train the trigger algorithm



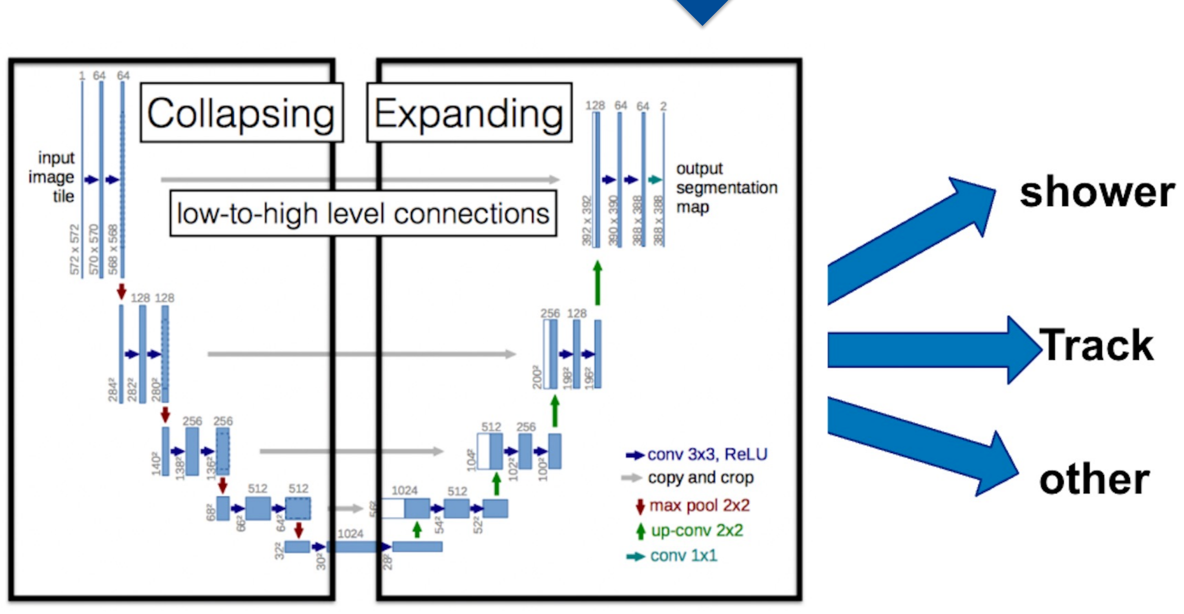


Fig 2 & Fig 3: Example input from a LArTPC detector (above), and illustration of the 2D CNN that is used to extract features for classification (left).

Ingredients for Machine Learning

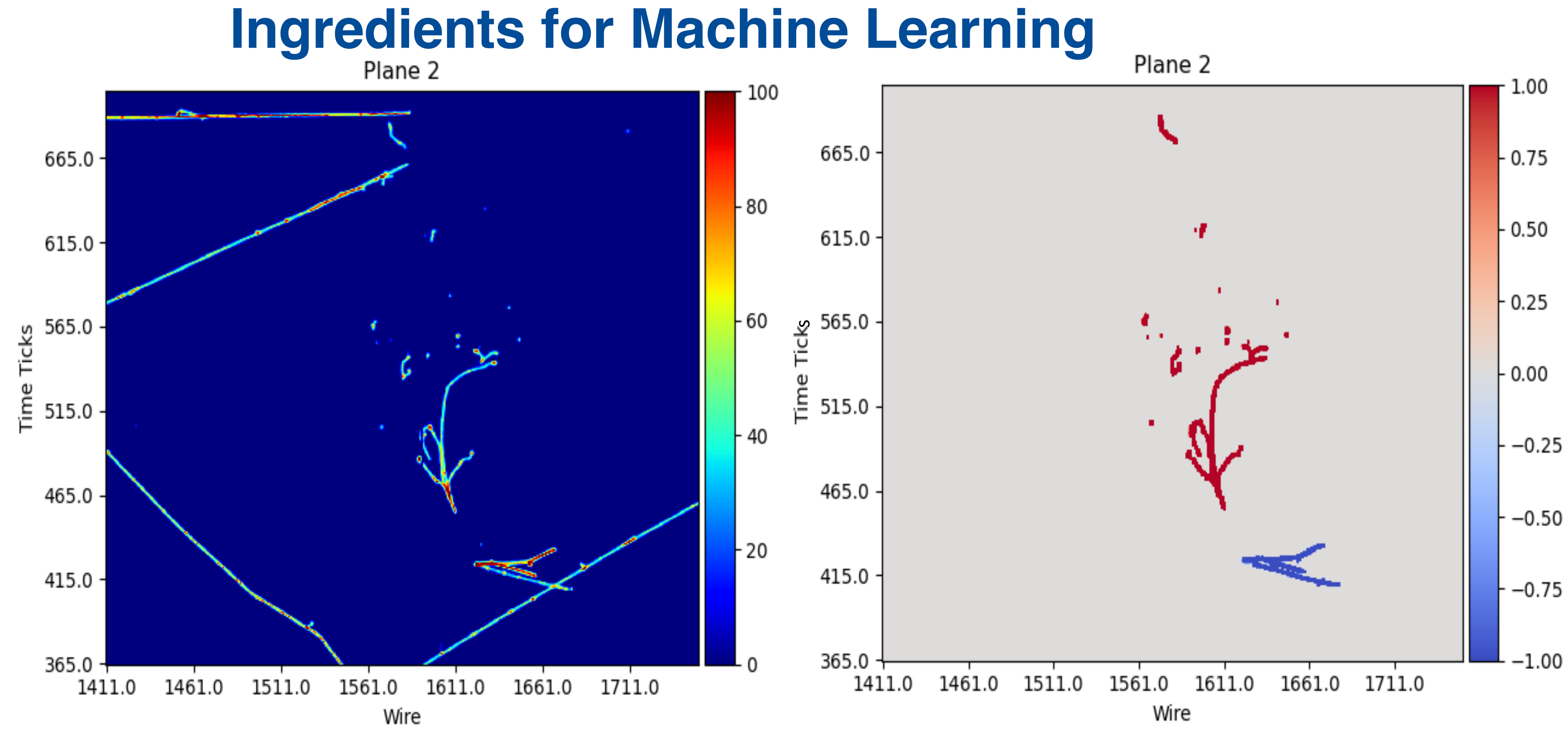


Fig 4 & Fig 5: Neutrino event in a LArTPC, pictured both in terms of ADC (left) and corresponding ground truth image used for machine learning (right). In the ground truth image, shower-like clusters are labeled in red, and track-like events are labeled in blue. Because DUNE is underground, cosmic events are not expected to be observed in DUNE detectors.

- Neutrino interactions in LArTPC detectors can be characterized as "shower-like" or "track-like," depending on the flavor of neutrino that caused the interaction
- This project aims to generate images of supernova neutrino interactions simulated by the Model of Argon Reaction Low Energy Yields (MARLEY) event generator for use in machine learning
- Ground truth images are generated by cropping by a certain window size around pixel with the highest ADC count

Putting It All Together: Pipeline

1. Simulate neutrino interactions

2. Convert events to images, and generate ground truth images

3. Sparse convolutional neural network classifies image pixels

4. Observe performance of sparse CNN

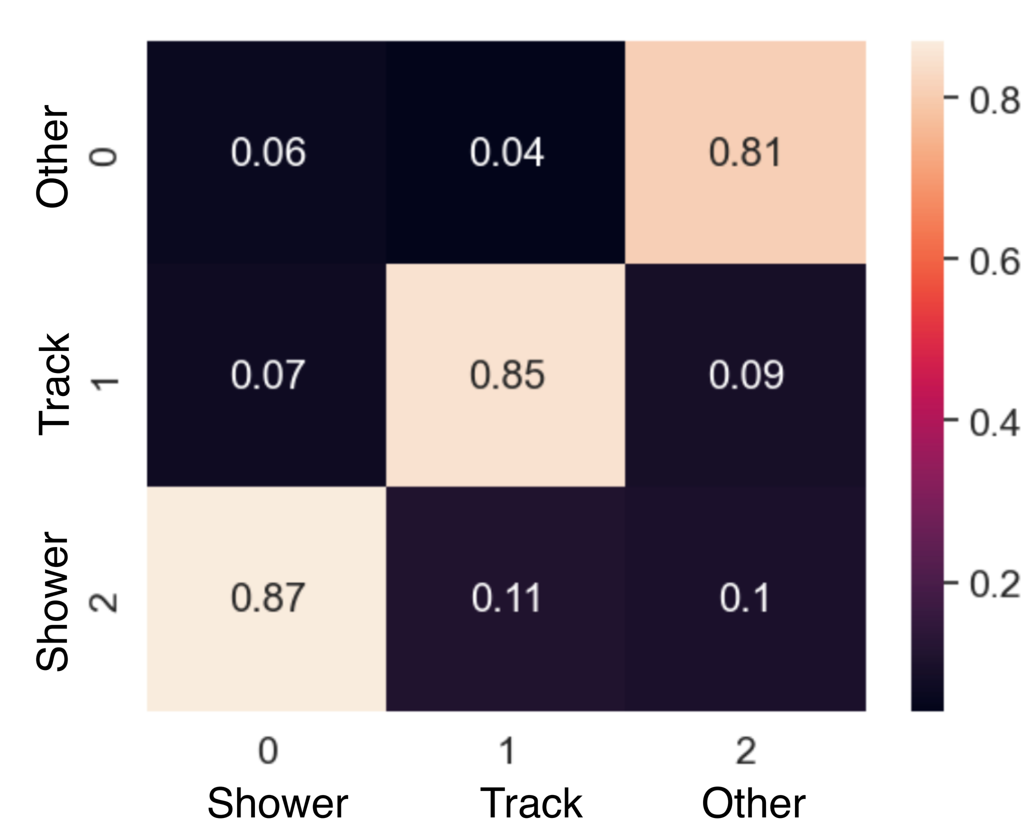


Fig 6: Preliminary performance results of sparse CNN approach.

Conclusion & Future Work

- Generating ground truth images is a step towards establishing the machine learning pipeline
- Future work will continue towards the goal of building a supernova neutrino trigger for DUNE using machine learning

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