Determining DUNE Convolutional Neural Network Neutrino Identification Biases

Remeza, Alissa (School: Harrison High School)

The Standard Model of Particle Physics (SM) describes physicists' best understanding of the fundamental makeup of the universe, yet neutrinos, part of the SM, exhibit unaccounted oscillations. Understanding anomalous neutrino properties will answer key questions posed about the universe, including evolution of the universe since the Big Bang, observed matter-antimatter imbalance, supernovae, and unification of forces. The Deep Underground Neutrino Experiment (DUNE) is a next-generation international experiment seeking to answer these questions. DUNE neutrino detection relies on liquid argon time projection chambers (LArTPCs) that produce detailed images of neutrino events. These events are classified by a trained Convolutional Visual Network (CVN), an image-processing neural network. This study improved DUNE analysis efforts by identifying erroneous or biasing factors influencing CVN predictions. Disproportionate effects on CVN accuracy from any custom modification was recorded for 800 event simulations and divided by event topology. Results showed significantly worsened performance (5.5 sigma, $p << 0.01$) with an obstruction of one of the three input images ("collection plane") to the CVN as well as significantly increased network errors for high energy, inelastic, and deep inelastic scattering (DIS) interactions (4.9 sigma, $p << 0.01$) for electron and muon neutrino events. These results suggest a bias in CVN training. Principally, there was an overreliance on the collection plane compared to the other input images. Moreover, there was evidence of poor training for highly inelastic events. This work enables more accurate training to provide comprehensive results for future neutrino research.

Awards Won:

Central Intelligence Agency: Second Award: $300