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Supervised Neural Network Modeling of the Light-Trapping Device in Dune's LArTPC Photon Detection System

This work presents the development and evaluation of an artificial neural network (ANN) as a supervised learning model to mimic the behavior of Arapucas, the light-trapping devices used in the DUNE Experiment, to model photon absorption probabilities. The input data is obtained from Geant4 simulations, specifically from the ArapucaSim module. The neural network model employed is a regressor model that receives as inputs the coordinates of a photon generator, along with positions on the Arapuca where the photon is absorbed and produces outputs consisting in absorption probability for each photon. After training the model, satisfactory accurate results were achieved, with significantly reduced computational time. While Geant4 simulations required hours to generate results, the trained neural network model produced comparable probabilities within minutes, with an error of less than 2%. This project emphasize the potential of NN models as efficient alternatives for simulating and predicting photon absorption probabilities by light-trapping devices with reduced time and cost, offering possibilities for further simulations and optimizations for experimental setups of the devices. The aim is to reduce the NN model error in the final steps of the project down to 0.5%.

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