Technical Details on Neural Net Analysis of Calorimeter Images

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DNN

We have found good performance results from using a dense neural network (DNN) on ECAL and HCAL slices. Starting with a 25x25x25 ECAL window and a 5x5x60 HCAL window, we first begin by flattening both calorimeter slices into a single one-dimensional input array. A rectified linear unit (relu) is applied directly to the input. (EDIT: this makes no sense and was a mistake. I should rerun the hyperparameter scan without this, and also add dropout to the input layer). Following this, we place X hidden layers with Y neurons each, where X and Y are optimized with a hyperparameter scan. Each layer is followed by a relu function and a dropout layer. The dropout rate is also determined via a hyperparameter scan.

Hyperparameter Scan

We run a hyperparameter scan over the following variables. The results of these scans are shown in Figure 1 and 2.

- number of hidden layers, between one and five
- number of neurons in each hidden layer, either 10, 30, or 50
- dropout rate, either 10%, 30%, or 50%
- learning rate, either 0.001, 0.01, or 0.1
- learning decay rate, either 0.001 or 0.01

Photon vs. Neutral Pion

The ROC for the best hyperparmeter point at ¡point¿ is shown in Figure 3, and the loss curves for both training and test samples at that point is shown in Figure 4.

Electron vs. Charged Pion

The ROC for the best hyperparmeter point at ¡point¿ is shown in Figure 5, and the loss curves for both training and test samples at that point is shown in Figure 6.

Figure 1: DNN hyperparameter scan over number of hidden layers and number of neurons per layer. Decay rate is held fixed at 0.001, and dropout rate is held at 0.1. (A) shows a learning rate of 0.001, (B) shows a learning rate of 0.01, and (C) shows a learning rate of 0.1.

Figure 2: DNN hyperparameter scan over decay rate and dropout rate. Learning rate is held fixed at ¡X¿, number of hidden layers is fixed at ¡Y¿, and neurons per hidden layer is fixed at ¡Z¿.

Figure 3: ROC for DNN trained at best hyperparameter point.

Figure 4: Loss history for training and test samples.

Figure 5: ROC for DNN trained at best hyperparameter point.

Figure 6: Loss history for training and test samples.