

A Deep Learning Approach to Particle Identification for the AMS Electromagnetic Calorimeter

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The Alpha Magnetic Spectrometer (AMS-02) is a high-precision particle detector onboard the International Space Station containing six different subdetectors. One of these, the Electromagnetic Calorimeter (ECAL), is used to measure the energy of cosmic-ray electrons and positrons and to differentiate these particles from cosmic-ray protons up to TeV energy.

We present a new deep learning approach for particle identification by taking as an input the energy deposition within all the calorimeter cells. By treating the cells as pixels in an image-like format, with effectively 2,592 features, we use various vision-based deep learning models as classifiers and compare their performances. Some of the models selected for training and evaluating range from simple convolutional neural networks (CNN) to more state-of-the-art residual neural networks (ResNet) and convolutional vision transformers (CvT).

The particle identification performance is evaluated using Monte Carlo electron and proton events from 100 GeV to 4 TeV. At 90% electron accuracy, for the entire energy range, the proton rejection power of our CvT model outperforms the CNN and ResNet models by more than a factor of 12 and 10, respectively. This shows promise for future use in the AMS-02 experiment and provides empirical evidence of newer architectures, such as transformers, outperforming CNNs for use in calorimeters.

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