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The Deep Learning Cosmic Ray Energy Reconstruction Pipeline for the GRAPES-3 Experiment

The mass independent energy reconstruction of cosmic rays is crucial for understanding their origin, acceleration, and propagation. Precise measurement of the primary energy can also lead to better mass classification and could enable energy dependent anisotropy maps for individual elements. The GRAPES-3 experiment located in Ooty consisting of 400 scintillator detector array placed 8 m apart covering an area of 25000 m^2 with a dedicated muon detector made of 3712 proportional counters, is designed to do these kinds of measurements. Previously electron size calibration curves have been used to find primary energy in the GRAPES-3 data analysis framework however significantly better precision can be established using deep learning models. This work implements a modular and hierarchical dynamic graph neural network based analysis pipeline adaptable to detector response while maintaining supervision over model learning. A variety of shower scenarios over logarithmically binned energy events for hydrogen, helium, nitrogen, aluminium and iron mass groups with varying shower core distances have been used for training and validation. Using mutual information and F-statistic feature selection criterias, we have compared the best possible feature combinations to achieve a much superior energy resolution. We also demonstrate the model's capability to reconstruct other shower variables and mitigate the impact of large shower core distances.

Collaboration(s)

GRAPES-3

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