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ATLAS Second-Level Electron/Jet Neural Discriminator based on Nonlinear Independent Components

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The ATLAS online filtering (trigger) system comprises three sequential filtering levels and uses information from the three subdetectors (calorimeters, muon system and tracking). The electron/jet channel is very important for triggering system performance as interesting signatures (Higgs, SUSY, etc.) may be found efficiently through decays that produce electrons as final-state particles. Electron/jet separation relies very much on calorimeter information, which, in ATLAS, is segmented into seven layers. Due to differences both in depth and cell granularity of these layers, trigger algorithms may benefit from performing feature extraction at the layer level.
This work addresses the second level (L2) filtering restricted to calorimeter data. Particle discrimination at L2 is split into two phases: feature extraction, in where detector information is processed aiming at extracting a compact set of discriminating variables, and an identification step, where particle discrimination is performed over these relevant variables.
The Neural Ringer is an alternative electron/jet L2 discriminator. Through Neural Ringer, the feature extraction is performed by building up concentric energy rings from a Region of Interest (RoI) data. At each calorimeter layer, the hottest (most energetic) cell is defined as the first ring, and the following rings are formed around it, so that all cells belonging to a ring have their sampled energies added together and normalized. A total of 100 ring sums fully describes the ROI. Next, a supervised neural classifier, fed from the ring-structure, is used for performing the final identification.
Independent Component Analysis (ICA) is a signal processing technique that aims at finding linear projections (s=Ax) of the multidimensional input data (x) in a way that the components of s (also called sources) are statistically independent (or at least as independent as possible). The nonlinear extension of ICA (NLICA) provides a more general formulation, as the sources are assumed to be generated by a nonlinear model: s=F(x), where F(.) is a nonlinear mapping. The Post-nonlinear (PNL) mixing model is a class of NLICA model that restricts the nonlinear mapping to a cascaded structure, which comprises a linear mapping followed by component-wise nonlinearities (cross-channel nonlinearities are not allowed).
In this work, a modification on the Neural Ringer discriminator is proposed by applying the
PNL model to the ring-structure for both feature extraction and signal compaction. In order to cope with different characteristics of each calorimeter layer, here the feature extraction procedure is performed in a segmented way (at the layer level). The neural discriminator is then fed from the estimated nonlinear independent components. The proposed algorithm is applied to different L2 datasets. Compared to the Neural Ringer, the proposed approach reduces the number of inputs for the neural classifier (contributing to reduce the computational requirements) and also produces higher discrimination performance.

Summary

This work addresses the second level (L2) filtering of ATLAS detector restricted to calorimeter data. It is proposed a modification on the Neural Ringer algorithm, which is an alternative for electron/jet discrimination. A nonlinear (PNL) independent component analysis model is applied to a ring-structure calorimeter data description for both feature extraction and signal compaction. A neural discriminator is then fed from the estimated nonlinear independent components. The proposed algorithm is successfully applied to different L2 datasets.

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