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Machine learning applied to particle classification in LAGO Water Cherenkov Detectors

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Astroparticles impinging on the Earth atmosphere cause a flux of secondary particles composed of three main components: electromagnetic, muonic and hadronic. When entering a Water Cherenkov Detector (WCD), these particles create Cherenkov radiation that is measured by photomultiplier sensors. The raw information captured by WCDs provides valuable insights into the temporal evolution of the cosmic rays flux, but not enough to differentiate each type of secondary particle contribution. In this work, we applied unsupervised Machine Learning (ML) techniques to find patterns in the data and applied clustering to provide this differentiation.

The data processing pipeline included the following stages: data acquisition, preprocessing, feature engineering and selection, modeling, and validation. Data acquisition involved using already available raw data from the WCD "Nahuelito" working at the LAGO site in Bariloche, Argentina. The preprocessing stage cleaned the data to result in pulses that resembled its expected Fast-Rise-Exponential-Decay form. After performing the feature engineering and selection, the resulting feature space was noisy which is especially challenging for most clustering algorithms. Thus, we propose the use of a density-based hierarchical clustering algorithm called Ordering Points to Identify the Clustering Structure (OPTICS) to tackle the complex feature space. OPTICS cluster the data according to regions of high density separated by regions of low density. Through its unique use of the reachability measure, several values were tested to result in clusters that could correspond to different secondary particles. Results look promising as clusters are located where secondary particle contributions are primarily expected to appear.

Poster fallback option for rejected abstracts for parallel oral presentations

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