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Point Cloud Machine Learning for Cell-to-Track Association: Enhancing Event Reconstruction in High Energy Physics

The ATLAS detector at CERN's Large Hadron Collider (LHC) is a complex system composed of multiple subdetectors, each designed to capture complementary aspects of particle interactions. Thus, accurate understanding of the physical phenomena under study requires effectively combining information from these components.

This work focuses on the key challenge of associating data from the inner tracker with the corresponding energy deposits in the calorimeter.

Current approaches tackle this problem in a modular fashion. First, hits in the tracker and calorimeter are reconstructed separately into tracks and topo-clusters, respectively. Second, tracks are iteratively associated with topo-clusters to improve particle identification and energy calibration in subsequent reconstruction steps. However, this strategy relies on rigid algorithms tuned to address reasonably well the most common known scenarios. Moreover, they fail to fully exploit the complementary information provided by the two subsystems. Consequently, errors in track and topo-cluster reconstruction are propagated to later stages, hampering accurate association.

To overcome these limitations, we propose a PointNet model for cell-to-track association. This approach enables the direct integration of tracking information into energy reconstruction, facilitates fine-grained association between tracks and individual calorimeter cells rather than whole topo-clusters, and leverages efficient point cloud data representations.
This methodology demonstrates promising results for enhancing offline reconstruction, particularly relevant for addressing the increased detector occupancy and event complexity anticipated in the High-Luminosity LHC era.

AI keywords

PointNet, Point Cloud Segmentation Task; Class Imbalance; Robust Loss and Metrics

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Track Classification: Patterns & Anomalies