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Real-Time Unsupervised Anomaly Detection in the CMS Level-1 Trigger

The CMS experiment at the LHC has entered a new phase in real-time data analysis with the deployment of two complementary unsupervised anomaly detection algorithms during Run 3 data-taking. Both algorithms aim to enhance the discovery potential for new physics by enabling model-independent event selection directly at the hardware trigger level, operating at the 40 MHz LHC collision rate within nanosecond latency constraints. AXOL1TL, an autoencoder-based anomaly detection model, has been integrated into the Level-1 Global Trigger system while CICADA focuses on low-level calorimeter data, using a convolutional autoencoder architecture distilled into a compact supervised model for efficient inference on resource-constrained hardware. Both algorithms selects anomalous events for further processing, primarily contributing to scouting data streams. In this talk, we present results from both algorithms with data recorded since 2024. We describe the architecture, deployment, and commissioning of each algorithm, as well as their integration into the CMS trigger system. We highlight the complementary nature of the two approaches and discuss prospects for improvements in real-time anomaly detection strategies at colliders.

Significance

References

Experiment context, if any

CMS experiment

Author: CMS COLLABORATION

Presenter: CMS COLLABORATION

Session Classification: Poster session with coffee break

Track Classification: Track 2: Data Analysis - Algorithms and Tools