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Improving Coincident Learning for Beam-based RF Station Fault Identification Using Phase Information at the SLAC Linac Coherent Light Source- 15'+5'

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The vast amount of data generated by accelerators makes manual monitoring impractical due to its labor-intensive nature. Existing machine learning solutions often rely on labeled data, manual inspection, and hyperparameter tuning, which limits their scalability. To address these challenges, we leverage coincidence learning—an unsupervised technique designed for multi-modal tasks—to automatically detect anomalies by identifying coincident patterns of behavior across two distinct segments of the feature space. Specifically, we focus on anomaly detection for radio-frequency (RF) stations at the SLAC Linac Coherent Light Source (LCLS). By analyzing shot-to-shot data from the beam position monitoring system alongside data from RF stations, we can identify the source of changes in the accelerator's status. Previous studies on RF stations produced reasonable results using time-asynchronous amplitude data, but ignored the richer information from time-synchronous phase data due to its complexity. We find that using neural networks to analyze the phase data enables the detection of anomalies that amplitude-based detection missed. Additionally, the time-synchronous phase data provides critical insights, allowing us to distinguish whether an RF station change occurs simultaneously with changes in the accelerator status or in response to them. Additionally, the rich information contained in the phase data facilitates clustering of anomalies into distinct categories, each with unique signatures. This categorization brings us closer to identifying the root causes of issues within the RF stations.

Author: LIANG, Jason (Stanford University)

Co-authors: RATNER, Daniel (SLAC); DARVE, Eric (Stanford University)

Presenter: LIANG, Jason (Stanford University)

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