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Enhanced quench detection at the EuXFEL through a machine learning-powered approach

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Within the context of the European X-Ray Free-Electron Laser (EuXFEL), where 800 superconducting radio-frequency cavities (SRFCs) are employed to accelerate electron bunches to energies as high as 17.5 GeV, ensuring safe and optimal accelerator operation is crucial. In this work, we introduce a machine learning (ML)-enhanced approach for detecting anomalies, with a particular focus on identifying quenches, which can disrupt the superconductivity of the SRFCs, leading to operational interruptions. Our method consists of a two-stage analysis of the cavity dynamics. We first leverage analytical redundancy to process the data, and generate a residual for statistical testing and anomaly detection. Subsequently, we employ machine learning to distinguish quenching events from other anomalies. Different algorithms have been explored, and adapted in order to take into account the specificity of the data at hand. The evaluation, based on 2022 data, demonstrates the superior performance of our approach when compared to the currently deployed quench detection system.

Primary Keyword

anomaly detection

Secondary Keyword

Tertiary Keyword

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