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Hybrid Autoencoder and Isolation Forest Approach for Time Series Anomaly Detection on ARRONAX Cyclotron Operation Data

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The Interest Public Group ARRONAX's C70XP cyclotron, used for radioisotope production for medical and research applications, relies on complex and costly systems that are prone to failures, leading to operational disruptions. In this context, research is being conducted to develop an active machine learning method for early anomaly detection to enhance system performance. One of the most widely recognized methods for anomaly detection is Isolation Forest (IF), known for its effectiveness and scalability. However, its reliance on axis-parallel splits limits its ability to detect complex anomalies, especially those occurring near the mean of normal data. This study proposes a hybrid approach that combines a Multi-Layer Perceptron Autoencoder (MLP-AE) with Isolation Forest to enhance the detection of complex anomalies. The Mean Squared Error (MSE) of the data reconstructed by the MLP-AE is used as input to the IF model. Validated on beam intensity time series data, the proposed method demonstrates a significant performance improvement, as indicated by the evaluation metrics, specifically the Area Under the Precision-Recall Curve (AUC-PR) and the F1 score.

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