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Machine learning for calibration drift forecasting in superconducting RF cavities

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Superconducting radio frequency (SRF) cavities in particle accelerators rely on accurately calibrated RF signals to assess cavity bandwidth and detuning, ensuring optimal performance. In practice, however, calibration drift due to humidity and temperature fluctuations over time poses a significant challenge, potentially resulting in suboptimal operation and reduced efficiency. This study explores how environmental variables such as humidity and temperature affect this phenomenon. Relative humidity, in particular, is difficult to control and has been shown to impact calibration drift strongly. Building on these insights, we introduce machine learning-based approaches to forecast both relative humidity and calibration drift in SRF cavities. By leveraging advanced algorithms and historical data on cavity operation and performance, we develop predictive models that identify patterns and trends indicative of relative humidity and calibration drift. Two approaches are presented in this work, including a polynomial NARMAX model and an attention-based deep neural network. These models enable real-time compensation and automated recalibration, improving system stability and efficiency.

Footnotes

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