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Research on Recognition of Quench and Flux Jump Based on Machine Learning

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The Institute of Modern Physics is developing the Fourth generation of Electron Cyclotron Resonance (FECR), which requires Nb3Sn superconducting hexapole magnets with higher magnetic fields and composite structures. For Nb3Sn superconducting magnets, they exhibit significant thermal magnetic instability, known as "flux jump". This characteristic can generate random voltage spikes during the excitation process of the magnet, leading to misjudgment of the Quench Detection System (QDS) and seriously affecting the normal operation of FECR. To solve this problem, this study uses machine learning algorithms and aims to build a simplified and efficient recognition model to effectively distinguish the phenomenon of overshoot and flux jump during the excitation process of Nb3Sn magnets. Based on the voltage data obtained from multiple excitation processes of Nb3Sn superconducting hexapole magnets, this paper extracted 27 quench samples and 25 flux jump samples, and extracted 33 features from each sample. Multiple machine learning algorithms were used to train and construct these data, and the accuracy of different algorithms was compared to ultimately explore the best recognition model. The experimental results show that the model only uses 5 features and achieves 100% classification accuracy on linear kernel SVM. By using this machine learning model, high accuracy and computational speed have been achieved in the recognition of magnetic flux jump and quench, which can provide reference for the optimization of subsequent FECR quench detection algorithms.

Primary Keyword

anomaly detection

Secondary Keyword

foundation models

Tertiary Keyword

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