Identifying Disruption Precursors by Anomaly Detection on Bolometer Tomography

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The JET baseline scenario [1] is being developed to achieve high fusion performance and sustained fusion power. However, with higher plasma current and higher input power, an increase in pulse disruptivity is being observed. Although there is a wide range of possible disruption causes [2], the present disruptions seem to be closely related to radiative phenomena such as impurity accumulation, core radiation, and radiative collapse [3]. In this work, we focus on bolometry to reconstruct the plasma radiation profile and, on top of it, we apply anomaly detection to identify the radiation patterns that precede disruptions, in a time frame that is relevant for disruption avoidance or mitigation.

The approach makes extensive use of machine learning. First, we train a surrogate model for plasma tomography [4] based on matrix multiplication; this provides a fast method to compute the plasma radiation profiles across the full extent of any given pulse. Then, we train a variational autoencoder (VAE) [5] to reproduce the radiation profiles by encoding them into a latent distribution and subsequently decoding them; as an anomaly detector, the VAE struggles to reproduce unusual behaviours, which includes not only the actual disruptions but their precursors as well. These precursors are identified based on an analysis of the anomaly score across all baseline pulses in recent campaigns.

References

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