

Role of Human Inputs in Cross-tokamak Disruption Prediction in Magnetic Confinement Fusion

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Disruption is a catastrophic event in tokamaks and represents a major challenge for future commercial fusion reactors. Although data-driven disruption prediction models trained on a single tokamak have successfully triggered disruption mitigation, obtaining large disruptive datasets for every new device is economically and operationally impractical. Cross-tokamak disruption prediction is therefore an essential transfer learning problem within machine learning. Differences in tokamak designs and operational conditions significantly affect data distributions between disruptive and non-disruptive phases. Additionally, diagnostic system variations across tokamaks directly influence whether the measured signals represent the same or similar plasma parameters. These factors present substantial challenges for achieving cross-tokamak disruption prediction using machine learning alone. This work highlights the important role of human inputs—including feature engineering, labeling strategies, and estimating data distributions for future tokamaks—in cross-tokamak disruption prediction research. Such human inputs enable improved predictive performance with fewer data from future tokamaks, while also providing interpretability to enhance model trustworthiness.

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