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A Hybrid Deep Learning architecture for general disruption prediction across tokamaks

Near-future burning plasma tokamaks will need to run disruption-free or with very few (<1%) unmitigated disruptions, therefore predicting disruptions on new tokamaks when they begin operating and disruption data is sparse, will be crucial to their success. This letter introduces a Hybrid Deep Learning (HDL) architecture for disruption prediction that achieves high predictive accuracy on the C-Mod, DIII-D and EAST tokamaks with limited hyperparameter tuning. The availability of data across different existing devices allows us to design numerical experiments to test transfer learning HDL capabilities. Surprisingly, it is found that the HDL algorithm achieves relatively good accuracy on EAST when including a small number of disruptive shots, thousands of non-disruptive data, and combining this with >1000 disruptive shots from DIII-D and C-Mod. This holds true for all permutations of the three tokamaks. This cross-machine, data-driven study shows clearly that the non-disruptive operational space is machine-specific but disruptive data contains crucial general knowledge about disruptions, independent of the considered device that can improve the predictive accuracy of the HDL predictor. The HDL architecture along with our cross-machine studies offer a general guideline for disruption prediction on ITER and future devices using very limited disruptive data from themselves but exploiting the thousands of disruptive discharges from various existing devices.

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Track Classification: Prediction and Avoidance