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Big Data Machine Learning for Disruption Predictions

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Building the scientific foundations needed to develop fusion power in a timely way can be facilitated not only by familiar "hypothesis-driven"/ first principles approaches but also by engaging modern big-data-driven statistical methods featuring machine learning (ML). An especially time-urgent and very challenging problem facing the development of a fusion energy reactor today is the need to reliably mitigate and avoid large-scale major disruptions in magnetically-confined tokamak systems such as the Joint European Torus (JET) – today and the burning plasma ITER device in the near future. These major macroscopic events lead to rapid termination of plasma discharges including severe impulsive heat loads damaging material components. Since they can damage the surfaces of the machine, which in turn can cost hundreds of millions of dollars to remediate, it is critical that the international fusion mission engage in multiple avenues to accelerate progress toward achieving the capability to reliably avoid such events with better than 95% predictive capability.
Accordingly, this paper will present results from the development and testing of ML-based-methodologies – an exciting R&D approach that is increasingly deployed in many scientific and industrial domains – to help provide much-needed guidance for disruption avoidance in JET. Working on this repository of the most important and largest (nearly a half petabyte and growing) data base of fusion-grade plasmas, JET statistical scientists have successfully deployed ML software interfaced with the large JET data base over the course of the past 6 years. This has produced encouraging results involving primarily the application of the support vector machine (SVM) approach. The goals for the present investigations are to: (i) achieve greater predictive reliability by improving the physics fidelity of the classifiers within the "supervised"ML workflow; and (ii) establishing the portability of the associated software beyond JET to other current tokamak systems and to ITER in the future. This will necessitate more realistic multi-dimensional, time-dependent, and much larger complex data instead of the simpler zero-dimensional, temporal data considered at present in all of the JET ML studies. Current analysis (via MDS+ tree) of the JET disruption data base has been enabled by formal approval of EUROfusion/JET.

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