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Machine learning for disruption warning on Alcator C-Mod, DIII-D, and EAST Tokamaks

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We find that disruption prediction using machine learning (ML), trained on large databases containing only plasma parameters that are available in real time on C-Mod, DIII-D, and EAST, differ substantially in performance among the three machines, implying that a universal real time disruption warning algorithm may be problematic. This could have important implications for disruption prediction and avoidance on ITER, for which development of a training database of disruptions may be infeasible. Whether or not disruption prediction can be improved by incorporating additional real time measurements, or with more sophisticated AI methods, is unclear.

The database for each tokamak contains parameters sampled at ~10^6 times throughout ~10^4 discharges, disruptive and non-disruptive, over the last 3-4 years of operation. We find that a number of parameters (e.g. $P_{\mathrm{rad}}/P_{\mathrm{input}}$, ℓ_{i}, n/n_{G}, $B_{n=1}/B_{\mathrm{T}}$) exhibit changes as a disruption is approached on one or more of these tokamaks. However, the details of these precursor behaviors are markedly different on each machine.

We use a shallow ML method known as Random Forests, applied to a binary classification scheme. We define the two classes as "*close to a disruption*" and "*far from a disruption or from a non-disruptive shot*". The threshold time that divides "close"from "far"is determined by optimising the classification prediction accuracy for each machine. We find that the timescales of disruption warning behavior are very different for the different machines, and that the fraction of correctly predicted disruption samples varies considerably, ranging from 74% for DIII-D, to just 35% for C-Mod. For C-Mod in particular, it is difficult to predict upcoming disruptions more than just a few milliseconds in advance.

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