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Real-time disruption prediction in multi-dimensional spaces with privileged information not available at execution time

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Focusing the attention on disruption mitigation, the locked mode (LM) signal is typically used as single signal to recognise incoming disruptions. However, if the LM signal is not available in real-time (as it will happen in the first JT-60SA discharges) or the LM signal is not reliable enough, simple predictors have to use other signals. This work shows that a line integrated density (LID) signal can be used to predict disruptions although its amplitude is not directly related to forthcoming disruptions (as in the case of the LM). Even more, the work shows that the prediction capability of the LID signal can be increased by using the LM as privileged information (V. Vapnik et al. Neural Networks 22 (2009) 544-557).
JET data collected in C-wall discharges have been used for test purposes. In particular, 1439 discharges in the range 65988 –73126 have been analysed (1354 non-disruptive and 85 disruptive shots). It is important to point out that only discharges with plasma current above 2 MA and disruptions whose plasma current at disruption time is greater than 1.5 MA have been taken into account.
In this work, the prediction of disruptions starts with anomaly detection to recognise the first disruptive behaviour in the dataset of discharges. The two-dimensional space of consecutive amplitudes of a LID signal is used. The first disruption is identified after applying an anomaly criterion to 42 non-disruptive shots and without obtaining any false alarm in such non-disruptive discharges. Then, a Support Vector Machine (SVM) model and an RBF kernel is created with LID data of the first disruptive discharge. By applying this SVM model to the rest of the discharges, the success rate is 98.82% and the false alarm rate is 42.32%. Unfortunately, as mentioned, the information concerning the LM is not considered due to its unavailability in real-time. However, at training time is possible to use LM data as privileged information in order to improve the decision function to recognise disruptive behaviours. By considering the LID data together with the LM signal at training time, a new SVM model and RBF kernel is generated for the real-time classification of disruptive/non-disruptive plasma behaviours. It should be emphasised that the prediction is carried out with the only input of the LID signal and without any LM data at prediction time. In this case, after applying the model to all the dataset discharges, the success rate is 94.12% and the false alarm drops to 10.27%. It is important to note that the models can be retrained in an adaptive way after missed alarms or false alarms.
To our knowledge, the use of privileged information in the terms described here is applied for the first time to disruption prediction in this work. Performances with privileged information (in this case, the LM) are better than performances with only the LID signal and these results open an important research line in fusion not only for disruption prediction but also for the development of any data-driven model based on machine learning.

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