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Transfer learning with a parsimonious disruption predictor: from JET C-wall to the metallic wall

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The Learning Using Privileged Information (LUPI) paradigm allows training classifiers with data not available at execution time. Recently, an application of the LUPI paradigm to the prediction of disruptions with extreme data scarcity was demonstrated [J. Vega et al. Nuclear Fusion 64 (2024) 046010 (12 pp)]. The objective of the previous reference was to test the development of an adaptive disruption predictor based on LUPI and its potential application to JT-60SA. To this end, a line integral density (LID) signal used for both training and real-time prediction is complemented with the mode lock signal as privileged information (i.e. the mode lock signal is only used for the training). The predictor was developed before the start of the JT-60SA operation and, therefore, it was trained with a JET specific database.

The present contribution investigates the potential of LUPI for transfer learning. The goal is to develop a parsimonious disruption predictor with JET C-wall discharges and to perform transfer learning to ITER-like Wall (ILW) shots. The term 'parsimonious'indicates two important properties of the predictor: that it is a purely data-driven approach without any a priori assumptions or conjectures, and that it performs adaptive predictions from scratch. Again, only a LID signal is used for real-time predictions and the predictor is trained with the LID signal and the mode lock as privileged information. The database consists of 439 C-wall discharges (409 non-disruptive shots and 30 unintentional disruptions) together with 471 ILW discharges (392 non-disruptive and 79 unintentional disruptive shots). An adaptive predictor is trained with the C-wall data. This means that a first predictor is generated with one disruptive and one non-disruptive discharge and re-trainings are carried out after missed or tardy alarms. After processing the 439 C-wall discharges, the last predictor is applied to ILW shots. Again, the predictor is re-trained adding ILW data after missed or tardy alarms. It is important to note that in both cases, C-wall and ILW, the predictor that results from a re-training only replaces the previous one when the outcomes (in terms of success, tardy and false alarm rates) with all the preceding discharges are better.

For the whole C-wall database, only two predictors have been generated (the initial model plus one re-training). The overall performances are: two tardy predictions, one missed alarm and three false alarms. This means a success rate of 96.7% (90% with positive warning time and 6.7% tardy detections) and 0.7% false alarms. After the transfer learning to the ILW, two re-trainings have been performed and the performances are: 5 missed alarms, 8 tardy detections and 32 false alarms. Therefore, the overall statistics of the transfer learning, taking into account both C-wall and ILW discharges, are: success rate 94.5% (85.3% with positive warning time and 9.2% of tardy alarms) and 4% of false alarms. The average warning time is 269 ms and, therefore, this approach to transfer learning based on a) prediction from scratch, b) two unique signals and c) the LUPI paradigm can be considered adequate for mitigation purposes.

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