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Disruption prediction on EAST with different wall conditions based on a multi-scale deep hybrid neural network

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Plasma disruption is a very dangerous event for future tokamaks and fusion reactors. Therefore, predicting disruption is crucial for ensuring the safety and performance of reactors. In this study, the features of two deep learning algorithms are integrated to establish a multi-scale hybrid network disruption predictor. Firstly, 43 diagnostic signals are extracted by a convolutional neural network (CNN), and the time information is learned by a long short-term memory network. The predictor is trained and tested on a database containing ~ 104 non-all-metal wall discharges. Its area under the receiver operator characteristic curve (AUC), which is a common performanc metric for deep learning algorithms, reaches 0.97, and the true positive rate is ~ 95.3% , while the false positive rate is ~ 8%. Since EAST was upgraded in 2020, the wall condition has been upgraded from non-all-metal to all-metal. To examine the robustness of the predictor, the EAST disruption predictor is migrated to the all-metal wall experiment for the first time. It is again tested under the all-metal wall experimental data, and its warning performance decreases significantly, with an AUC of only 0.79. To improve the robustness and sensitivity of the predictor against disruptions, the convolutional attention mechanism is introduced into the CNN. After training and testing with the same data set, the warning performance for the all-metal wall data is improved, with the AUC value increasing to 0.84. To further improve the robustness of the predictor, the t-SNE algorithm is employed to explore the difference of the sample distribution before and after EAST upgradation, and the transfer learning algorithm is used to reduce this difference. By applying transfer learning to a small amount of discharges from the all-metal wall data, the warning performance in the all-metal wall experiment is further improved, and the AUC value increases to 0.93.

Summary

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