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Plasma control with artificial intelligence on EAST

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Robust control of tokamak plasma is still one of the most challenges for a fusion reactor due to the complicated plasma dynamics together with its response with complicated structures and actuators and the extreme control requirements. In recent years, artificial intelligence showed its great potential in predication of plasma states and in control of plasma equilibrium. On EAST, all disrupted shots have been collected to establish a disruption database. Then AI models by CNN, LSTM, Random Forest and XGboost were trained to predict disruptions by impurity burst, MARFEE and other unknown reasons. Cross machine disruption prediction has been done with Alcator C-mod and DIII-D disruption database in collaboration with MIT team. In order to get more accurate and quicker real-time estimation of the plasma position and vertical growth rate, we trained a neural network model by using off-line EFIT equilibrium data. Real-time performance and accuracy haven been verified in the experiments. By using the model by system identification to the plasma response with Low Hybrid Wave in the experimental to train reinforce learning (RL) model to train a controller, a reliable plasma pressure control was demonstrated. By using a neural-network model, which was trained by a rigid state space model of the plasma vertical response, to extract the controller parameters in real-time, a self-adaptive controller has been applied to experiments. More robust vertical control has been achieved. Moreover, to increase the robustness of the vertical stability control and get more reliable decoupling with the slow vertical motion, Deep Deterministic Policy Gradient algorithm was used to train another vertical controller. Robust Adversarial Reinforcement Learning was also used to train the controller to get rid of as much as possible the possible fast control coil over current caused by the perturbation by slow vertical motion. Simulation showed good performance of the controller.

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