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Development of plasma control algorithm design via machine learning

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Machine learning has garnered increasing attention within the fusion community in recent years, with much of the focus going toward implementation of disruption predictors. However, disruption detection is but one possible area in which the large body of fusion experimental data, accrued over decades, can be put to use. In particular, this data can be utilized to assist in the implementation of closed loop controllers, either through augmentation of existing model-based approaches, or via purely data-driven methodologies.

In this work we explore the use of machine learning for vertical stability control of the DIII-D tokamak. We describe the application of a search and machine learning computing toolchain for system identification of highly non-linear coil/vessel/plasma interactions as a function of equilibrium state. Extraction of the training data used in this process is achieved at rates over two orders of magnitude greater than previously attainable. The identified system model is then integrated with a model predictive controller and tested in simulation. Additionally, we investigate creation of a purely data-driven vertical control algorithm (using, for example, reinforcement learning). Development toward integration of these algorithms for real time use in the DIII-D plasma control system is discussed. The use of large-scale machine learning techniques for plasma control is still novel within the fusion community, and this work provides a template for future data-driven approaches.

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