Neural net modeling of equilibria in NSTX-U

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Traditional methods for equilibrium reconstruction and shape control rely on physics-based models and solvers such as real-time EFIT. Due to the constraint of operating in real-time, these solvers have less accuracy and availability than the offline versions. Neural networks (NNs) can offer a bridge between this performance and speed tradeoff. In this work, we train Eqnet, an NN model capable of predicting equilibria on the NSTX-U tokamak. Eqnet is trained on the offline reconstruction (EFIT01) and we demonstrate that this can improve some performance issues related to availability, induced vessel currents, and insufficient convergence. We also develop Pertnet, a NN capable of predicting the nonrigid plasma response, a term that arises in shape control modeling. These networks are part of a suite of tools being developed for NSTX-U for fast prediction, optimization, and visualization of plasma scenarios. The NNs are trained with different combinations of inputs and outputs in order to offer flexibility in use cases. In particular, Eqnet can use magnetic diagnostics as inputs and act as an EFIT-like reconstruction algorithm, or, by using pressure and current profile information the NN can act as a forward Grad-Shafranov equilibrium solver. We report strong performance for all NNs indicating that the models could reliably be used within closed-loop simulations or other applications.