

Imitation Learning-Based Feedforward Current Optimization for Tokamak Plasma Control

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Accurate real-time control of plasma equilibrium is critical for stable tokamak operation. This study proposes a novel imitation learning framework to predict optimal feedforward currents for poloidal field (PF) coils based on plasma state observations. The model ingests high-dimensional state vectors including plasma boundary coordinates, plasma current centroid positions, and total plasma current. Through DTW-based discharge selection and behavioral cloning of expert trajectories, the neural network directly maps states to 12-dimensional PF coil currents.

Experimental validation on EAST tokamak data is currently underway, with preliminary simulations indicating the potential to achieve >92% trajectory tracking accuracy in reconstructing expert PF current sequences, computational latency below 2 ms per inference, and enhanced robustness to plasma perturbations through DTW-curated training data. This work pioneers the integration of imitation learning into magnetic confinement fusion control systems, establishing a scalable framework for adaptive feedforward compensation that could significantly improve discharge stability in next-step devices such as ITER.

Keywords:

Imitation learning, Plasma control, Feedforward prediction, Dynamic Time Warping (DTW)

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