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AI-based profile control with RTCAKENN on DIII-D: Toward robust operation under diagnostic degradation and failure for FPP

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In future fusion power plants, full diagnostic coverage may not always be available due to radiation damage, access limitations, or cost constraints. To explore profile control under such conditions, we tested a real-time control scheme on DIII-D that is robust against the loss of primary kinetic diagnostics. The system uses RTCAKENN[1], a neural network trained to infer seven kinetic profiles—including density, temperature, and rotation—based only on real-time-compatible inputs. In experiments, we evaluated its performance by selectively removing inputs from diagnostics such as Thomson scattering or charge exchange. Even with missing data, RTCAKENN continued to provide profile estimates with sub-5 ms latency and promising agreement with available measurements. These inferred profiles were used by a model predictive controller to adjust actuators like neutral beam injection and gas fueling. This approach may offer a practical solution for profile control in reactor environments where some diagnostics are unavailable or degraded.

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References:
[1] R. Shousha et al. NF 64 026006, 2024

Author: SHOUSHA, Ricardo (Princeton Plasma Physics Laboratory)

Co-authors: Mr ROTHSTEIN, Andy (Princeton University); Dr KOLEMEN, Egemen (Princeton University); Mr FARRE-KAGA, Hiro (Princeton University); Dr SEO, Jaemin (Chung-Ang University); Dr CHEN, Jiayu (Carnegie Mellon University); Dr STEINER, Peter (Princeton University); Mr SONKER, Rohit (Carnegie Mellon University); Dr KIM, SangKyeun (Princeton Plasma Physics Laboratory); Dr HONG, Suk-Ho (General Atomics); Dr ZHU, Yilun (University of California, Davis); Dr XING, Zichuan (General Atomics)

Presenter: SHOUSHA, Ricardo (Princeton Plasma Physics Laboratory)

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