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Reinforcement Learning for Rampdown Scenario Design and Active Disruption Avoidance

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Plasma disruptions pose a major threat to burning plasma devices. As a part of avoidance, mitigation, resilience, and recovery (AMRR) efforts, it is desirable to develop emergency shutdown scenarios that 1) minimize ramp down time while avoiding disruptions, and 2) adapt to the real-time conditions of the plasma. Prior works involved performing a constrained trajectory optimization on the transport solver RAPTOR to minimize ramp down time while avoiding disruptive limits, but such an approach is not immediately amenable to allowing the plasma control system (PCS) to adapt to new real-time conditions. In this work, we adopt a reinforcement learning approach to solving this problem by training a control policy on a POPCON-like (Plasma OPerational CONtours) model that outputs current ramprate, auxiliary heating, and fueling commands. As the control policy is a small neural network, it is computationally cheap enough to be used for real-time active disruption avoidance. In addition, we demonstrate how this control policy can aid in offline scenario design by inputting trajectories generated from policy rollout into RAPTOR to produce faster rampdowns that avoid disruptive limits.

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