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A novel tokamak plasma control method using reinforcement learning

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The deep reinforcement learning (RL) technique has performed above the human-level in nonlinear and high-dimensional actuation problems in different fields. The RL agent learns a control policy to maximize a reward function defined by the user in a given environment. By setting higher rewards the closer we get to the desired plasma state in a tokamak environment, RL can also be applied to control and optimize plasma in tokamak. Recently, technologies using RL to control and optimize plasma have been applied, showing promising achievements in actual tokamak experiments [1-3].

In this presentation, we will introduce the development of a technology that provides actuator control to reach the target plasma state in the KSTAR tokamak using RL. Firstly, we developed a data-driven tokamak simulator, which corresponds to the virtual tokamak environment needed for RL training. This process utilized five years of experimental data from KSTAR, enabling us to construct an environment that provides plasma responses close to experiments at high computation speed. Secondly, we trained an RL agent in this simulation environment to control the tokamak actuators and reach randomly given target plasma states. Finally, using the actuator trajectories provided by the RL agent for several multivariate targets consisting of (β_p, q_{95}, l_i), we conducted KSTAR experiments and demonstrated that we could reach plasma states quite close to the targets, as shown in Figure 1.

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References

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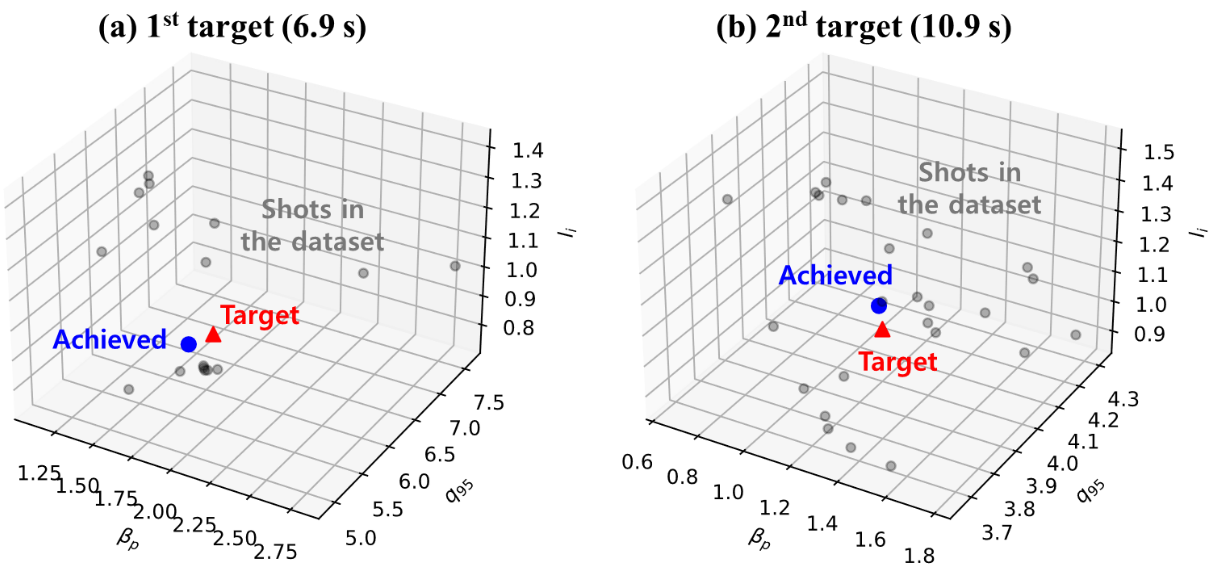

Figure 1. Comparison between the target plasma state and the state achieved by the control trajectory of the trained RL agent.