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Virtual KSTAR and potential AI/ML applications in the digital twin platform

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The transition from present day tokamaks to DEMO reactor will pose great scientific and technological challenges. As a way to overcome those challenges, we have launched the development of the Virtual-KSTAR (V-KSTAR), which is based on digital twin technology. It is aiming to establish a unified machine/fusion data framework and simulation workflows. By elevating the maturity of the digital twin technology through analyzing and predicting tokamak experiments, V-KSTAR would become a crucial step toward the design and construction of the Korean DEMO reactor.

Over the past years, a significant progress has been made in the development of V-KSTAR, including the conversion of legacy data and the implementation of workflows which are designed for specific experimental analyses. Initially, the focus has been on the between-shot analysis of KSTAR experiments, facilitating the validation of simulation codes and aiding experimental analysis to improve machine operation. To enhance the performance of simulation codes, we have adopted parallelization techniques and exploited GPU-based acceleration on modern supercomputing environment. However, these advancements alone turned out to be insufficient to realize a comprehensive digital twin. Consequently, incorporating additional acceleration techniques such as artificial intelligence (AI) and machine learning (ML) is indeed essential.

In this presentation, we will report the current status of the V-KSTAR development, outlining our plans for the integration of AI and ML. We will discuss strategies for training the models, including the acceleration of simulation codes and the acquisition of simulation data. Furthermore, we will discuss broader aspects of AI/ML technologies, which may contribute to the realization of more advanced fusion digital twin in future.

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