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Agentic AI, Physical AI, AI Scientist, and Superfacility for Accelerator Facilities

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Recent progress in Artificial Intelligence (AI) has accelerated the development of high-performance Large Language Models (LLMs), with leading global companies releasing new generations every few months. The emergence of GPT-5, exhibiting expert-level reasoning capabilities, has reduced hallucination errors to only a few percent, suggesting the feasibility of near-zero-hallucination LLMs in the near future. This rapid advancement is reshaping the research landscape, where tasks once requiring large teams can now be executed by a single expert working collaboratively with an intelligent AI Scientist. In accelerator science, Agentic AI and Physical AI are being introduced to enhance accelerator design, diagnostics, autonomous operation, fault detection, and predictive maintenance. To maximize scientific productivity, the Superfacility concept integrates accelerator beamlines, high-performance computing (HPC), big-data centers, and AI platforms through high-speed networks, enabling autonomous and data-driven experimentation. In this paper, we present our recent developments of ELEGANT–LLM–based Agentic AI, designed to estimate magnetic-field and alignment tolerances and to improve the dynamic aperture of the Korea-4GSR light source project. We also describe EPICS–LLM–based Physical AI for autonomous accelerator operation. Furthermore, the concepts of the AI Scientist and Advanced Superfacility platform for accelerator beamlines are introduced, demonstrating the potential of AI-driven accelerator facilities in achieving intelligent, self-optimizing research infrastructures.

Paper submission Plan

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