Online tuning of particle accelerators with reinforcement learning and comprehensive surrogate models*

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Abstract

Particle accelerators are used in a wide array of medical, industrial, and scientific applications, ranging from cancer treatment to understanding fundamental laws of physics. While each of these applications brings with them different operational requirements, a common challenge concerns how to optimally adjust controllable settings of the accelerator to obtain the desired beam characteristics, as well as how to maintain those through characteristics through continuous control (for example, dynamic control of RF cavities, beam trajectories, etc). For example, at highly flexible user facilities like the Linac Coherent Light Source (LCLS) and FACET-II at SLAC National Accelerator Laboratory, requests for a wide array of custom beam configurations must be met in a limited window of time to ensure the success of each experiment – a task which can be difficult both in terms of tuning time and the final achievable solution quality. At present, the operation of most accelerator facilities relies heavily on manual tuning by highly-skilled human operators, often with the aid of simplified physics models and local optimization algorithms. As a complement to these approaches, fast-executing surrogate models coupled with techniques from deep reinforcement learning can support rapid adjustments between custom beam setups, fine-tuning of setups, and continuous online control. I will discuss developments in this area for accelerators at SLAC and also highlight a few examples from other accelerator facilities.

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