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Xopt and Badger: a machine learning ecosystem for real-time accelerator control and optimization

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Machine learning (ML)-based black-box optimization algorithms have demonstrated significant improvements in accelerator optimization speed, often by orders of magnitude. However, deploying these algorithms in real-time facility control remains challenging due to the specialized expertise and infrastructure required. To bridge this gap, we introduce the Xopt ecosystem, a versatile suite of tools designed to make advanced ML-based optimization accessible to the broader accelerator community. This ecosystem includes Xopt, a modular Python framework that facilitates the integration of ML-based optimization algorithms with arbitrary control problems, and Badger, a graphical user interface built on top of Xopt, which enables seamless deployment of ML algorithms in real-time control systems. The Xopt ecosystem has been successfully applied towards solving challenging real-time control problems at leading international accelerator facilities, including SLAC, LBNL, Argonne, Fermilab, BNL, DESY, and ESRF, demonstrating its effectiveness in real-world optimization tasks. In this presentation, we provide an overview of Xopt's capabilities and illustrate its impact through case studies from SLAC accelerator facilities including LCLS, LCLS-II, and FACET-II.

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Footnotes

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