Bayesian Techniques for Accelerator Characterization and Control*

Ryan Roussel
Stanford National Accelerator Laboratory (SLAC)

Abstract

Accelerators and other large experimental facilities are complex, noisy systems that are difficult to characterize and control efficiently. Bayesian statistical modeling techniques are well suited to this task, as they minimize the number of experimental measurements needed to create robust models, by incorporating prior, but not necessarily exact, information about the target system. Furthermore, these models inherently take into account noisy and/or uncertain measurements and can react to time-varying systems. Here we will describe several advanced methods for using these models in accelerator characterization and optimization. First, we describe a method for rapid, turn-key exploration of input parameter spaces using little-to-no prior information about the target system. Second, we highlight the use of Multi-Objective Bayesian optimization towards efficiently characterizing the experimental Pareto front of a system. Finally, we discuss the use of hybrid Bayesian models to connect computational and experimental models. Throughout, we describe how unknown constraints and parameter modification costs are incorporated into these algorithms.

* Title and Abstract of an Invited Presentation at the Workshop: AI/ML for Particle Accelerator, X-Ray Beamlines and Electron Microscopy at Argonne National Laboratory, November 1-3, 2021.