AKBP 14: Focus session: Machine Learning

Time: Thursday 9:30–11:30 Location: MOL 213

Invited Talk AKBP 14.1 Thu 9:30 MOL 213
Application of Machine Learning to Beam Diagnostics — •Elena Fol — CERN, 1211 Geneva 23, Switzerland — Goethe University, 60438 Frankfurt am Main, Germany

Machine Learning (ML) techniques are widely used in science and industry to discover relevant information and make predictions from data. Recently, the application of ML has grown also in accelerator physics and in particular in the domain of control and diagnostics. The target is to provide an overview of ML techniques demonstrating their potential to be efficiently applied to accelerator problems. A short summary of recent achievements and current studies will be presented, followed by the application of ML to beam optics measurements and corrections in the Large Hadron Collider at CERN.

Invited Talk AKBP 14.2 Thu 10:00 MOL 213
Towards Micro-Bunching Control at Storage Rings with Reinforcement Learning — •Tobias Boltz — KIT

The operation of ring-based synchrotron light sources with short electron bunches can provide intense coherent synchrotron radiation (CSR) up to the THz frequency range. Yet, the continuous reduction in bunch length and stable emission of CSR are limited by the self-interaction of the bunch with its own radiation field. Above a machine-specific threshold current, the emitted CSR power starts fluctuating rapidly and continuously due to the formation of dynamically evolving microstructures in the longitudinal charge distribution. As these small spatial structures lead to an increased emission of CSR at higher frequencies, this effect might also be desirable dependent on the application at hand. In this contribution, we discuss complementary approaches to both excitation and mitigation of the micro-bunching dynamics in order to optimize the emitted CSR for each application individually. Therefore, we motivate the usage of an RF modulation scheme to exert control over the longitudinal beam dynamics and illustrate how reinforcement learning methods can be applied to optimize towards different objective functions.

Invited Talk AKBP 14.3 Thu 10:30 MOL 213
Towards Reinforcement Learning Based Optimization at the Light Source BESSY II — •Luis Vera Ramirez — luis.vera_ramirez@helmholtz-berlin.de

The incorporation of Machine Learning tools in order to improve the performance and the experimental setups at the large-scale user facility BESSY II is an important part of the next years' roadmap at the Helmholtz-Zentrum Berlin. In this talk, we will focus on several use cases based on Reinforcement Learning (RL) based on simulations as well as experiments with real machine data. These experiments are currently being developed by both the beamline and the accelerator groups and include, among others, the optimization of booster current and injection efficiency (already carried at out the machine) as well as first RL-approaches regarding automatic parameter tuning for beamline raytracing.

Invited Talk AKBP 14.4 Thu 11:00 MOL 213
Advances in reinforcement learn for accelerator tuning at CERN — •Simon Hirlaender — University of Malta / CERN

The preservation of reliable and stable performance of accelerator complexes demands arduous effort. Hence to fully exploit the potential of accelerator-based facilities around the world, tackling unavoidable problems as drifts, hysteresis or fast set-up after configuration changes in an automated, efficient manner has become increasingly important. Well-known numerical optimization algorithms, as well as modern techniques based on reinforcement learning (RL), found their way into the control rooms for that purpose. This talk will address the main challenges with RL for accelerator operation and discuss recent progress at the CERN accelerator complex, especially at the LINAC4 accelerator and the AWAKE electron line. Various successful tests employing model-free optimization as well as highly sample efficient deep RL algorithms with more than ten degrees of freedom for problems such as trajectory steering and optics matching are covered. The method of transfer learning, where the controller was trained purely on simulated data, could be demonstrated. Besides, the training of a controller in disentangled latent space representations of image-based measurements was shown. The next boost in sample efficiency is expected from model-based reinforcement learning algorithms that learn the dynamics of a particular process explicitly and in this way, can reduce the interaction with the real environment as the accelerator time by orders of magnitude. In many cases, RL training is unfeasible otherwise. These models are uncertainty aware and offer promising properties for a wide range of possible applications, where an apriori model is not available. These studies mark the first mile-stones towards a self-tuning accelerator at CERN.