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Machine Learning Tools for Heavy-Ion Linac Operations

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At a heavy ion linac facility, such as ATLAS at Argonne National Laboratory, a new ion beam is tuned once or twice a week. The use of machine learning can be leveraged to streamline the tuning process, reducing the time needed to tune a given beam and allowing more beam time for the experimental program. After establishing automatic data collection and two-way communication with the control system, we have developed and deployed machine learning models to tune and control the machine. We have successfully trained online different Bayesian Optimization (BO)-based models for different sections of the linac, including the commissioning of a new beamline. We have demonstrated transfer learning from one ion beam to another allowing fast switching between different ion beams. We have also demonstrated transfer learning from a simulation-based model to an online machine model and using Neural Networks as the prior-mean for BO optimization. Following a failed attempt to deploy Reinforcement Learning (RL), we have finally succeeded in training a model online for one beam and deploy it for the tuning of other beams. More recently, these models are being generalized to other sections of the ATLAS linac and can, in principle, be adapted to control other ion linacs and accelerators with modern control systems.

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Tertiary Keyword

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