

# Applying Reinforcement Learning to Particle Accelerators: An Introduction

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Reinforcement learning is a form of machine learning in which intelligent agents learn to solve complex problems by gaining experience. In current research, agents trained with reinforcement learning perform better than their human counterparts on problems that have historically been difficult for machines to solve. Particle accelerators are among the most advanced high-tech machines in the world. Modern scientific experiments place the highest demands on beam quality, making particle accelerator control extremely complex. Reinforcement learning is a promising avenue of research that has the potential to improve existing accelerator control solutions and enable new ones that have previously been impossible with conventional methods. The barrier of entry into reinforcement learning, however, is high and slows its adoption in the accelerator field. In this tutorial, we apply reinforcement learning to the task of tuning transverse beam parameters in a real-world accelerator beam line and focus in particular on solving the issues that arise in the context of particle accelerators, such as the high cost of samples, a large sim2real gap and the high non-linearity of the control and optimisation tasks under investigation.

## Primary Keyword

reinforcement learning

## Secondary Keyword

AI-based controls

## Tertiary Keyword

ML-based optimization

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