

Artificial Intelligence and Particle Accelerators: potential applications at PRAE

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Modern particle accelerator projects, such as PRAE or MYRRHA¹, have very high stability and/or reliability requirements that can reach or even exceed the performances allowed with usual control systems. Therefore, there is a strong need to develop new control systems and strategies in order to meet specifications. In this context, Artificial Intelligence and especially Machine Learning have the potential to provide a solution. Although Machine Learning has existed for many decades, it is only recently that it started to attract more and more attention thanks to AlphaGo² (developed by DeepMind) winning against Lee Sedol at the game of Go two years ago. This demonstrated the ability of artificial neural networks to demonstrate complex behavior i.e. take adequate decisions that balances short-term and long-term objectives along with local and global strategies in an evolving environment. Coincidentally, driving a particle accelerator requires essentially the same ability. It is necessary to configure the accelerator correctly to obtain the expected beam while external conditions keep changing and with respect to the fact that configurations that may seem good locally can have disastrous impact on the beam dynamics further down the accelerator.

During the talk, we will discuss about Deep Blue³ (won against the chess world champion in 96 and in 97), AlphaGo and its successor, AlphaGo Zero, to illustrate the abilities as well as the shortcomings of Artificial Intelligence. This will also allow us to see how Artificial Intelligence in reality differ from its depiction in science-fiction and some press articles. With that in mind, we will then talk about the potential applications to particle accelerators using recent works and published results. In particular, we will explore how the future operators and scientists of PRAE may benefit from the integration of Artificial Intelligence.

¹ <https://myrrha.be/>

² Mastering the game of Go with deep neural networks and tree search, D. Silver *et al.*, doi:10.1038/nature16961

³ Behind Deep Blue, Feng-hsiung Hsu, Princeton University Press, ISBN 0691090653