Machine learning for particle physics

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In the field of particle physics the recent progress of Machine Leaning has resulted in a strong interest to apply novel techniques to many computational problems. The Viennese Institute of High Energy Physics covers a broad range of experiments, ranging from the search for unknown physics in high energy collisions, to precision measurements of e.g. the Higgs boson to the search for dark matter. Several groups at HEPHY have picked up the topic. We find applications of machine learning in the context of optimal readout of the hardware of the experiments, in analysis of the physics data, and even in theoretical physics.A very useful class of algorithms is supervised learning for classification and regression.

A brief (and incomplete) list of current activities is as follows:

- For the CMS experiment deep networks with recurrent and convolutional layers are used to discriminate between different types of leptons
- For the Belle2 experiment a multi-layer perceptron is applied to regress the time that a particle hit a silicon detector
- For the CRESST experiment convolutional neural networks separate signal events from background events in the search for dark matter
- In a phenomenological study, a Bayesian Monte Carlo Markov Chain method is used to quantify how much we learned about supersymmetry from the LHC results in CMS

In a joint effort of HEPHY and AI Lab Linz we have also explored the idea to use physics concepts to improve Machine Learning algorithms by reframing generative adversarial network (GAN) as a quantum mechanical problem. This aims to exploit amenable features of quantum mechanics (Schroedinger equation in very high dimensions) such as the notion of superpositions of wave functions, and ideally also tunneling effect to realize an efficient algorithm.

Machine learning will play also an important role at the new computing facility at the Vienna Biocenter, where modern GPUs can be used in the vicinity of the large data sets of the experiments.