Abstract of "Design and implementation of the monitoring and analysis software platform for upgraded LHCb VELO detector and search for a new fitting method based on computational intelligence approach for $B \rightarrow Dh$ decays."

The document brings together two related research objectives in the context of applications in High Energy Physics. The first topic concerns the Vertex Locator (VELO), a vertex detector at the LHCb experiment at CERN. Since 2018, the LHCb experiment has been in the phase of a major upgrade - Upgrade I, where the technology of the selected detectors in the LHCb spectrometer is adjusted to the increased instantaneous luminosity. The spectrometer will have to handle about five times as many concurrent collisions as before and operate at an increased readout frequency from 1.1 MHz to 40 MHz. The upgraded VELO takes advantage of the VeloPix ASIC - a pixel readout chip, where each pixel features its own electronic readout channel. The ASICs of the highest occupancy will be only 5.1 mm off the axis of the LHC beams. The dissertation presents the calibration of VELO, as well as the decoders, monitoring, and data simulation incorporated into the software platform Vetra. It further proposes and discusses a few applications of the software for certain studies of pixel detectors in general.

The second part is a search for novel tools based on Machine Learning (ML) in particle decays and mass spectrum reconstruction. Smart algorithms have had many successes in recent years, such as image generation or intricate decision-making. Although the number of emerging techniques is remarkable, their application in other than native fields often lags behind the new inventions. An overview of modern methods and their applications is outlined in the thesis. In particular, the use of Deep Neural and Generative Adversarial Networks (DNN, GAN) in the problem of generating physics data samples is demonstrated. The potential applications of deep models for mass spectrum fitting is shown, as well as heuristic optimization methods used in the process. Such methods can show higher efficiency in estimation than conventional, like maximum likelihood. Since imperfect measurements made by complex detectors affect the reconstruction process, the ML-based approach could bring new solutions to the problem and complement the statistical methods used in modelling so far.

Paweł Kopciewicz
03.01.2023 Kraków