Thematic CERN School of Computing on Machine Learning 2024

Sunday 13 October 2024 - Saturday 19 October 2024

MedILS, Split, Croatia

Scientific Programme

The school will focus on the theme of **Machine Learning** and **Artificial Intelligence** applied to **Data Analysis** and **Accelerator Technology**. The programme will offer 22 hours of lectures and hands-on exercises, and student presentation sessions.
The final programme and lecture timetable will be released before the beginning of th school.

Track 1: A summary of Machine Learning Methods

Introduction to data analysis
What is a PDF, frequentistic and bayesian probabilities, parameter estimation with the likelihood method, hypothesis testing, Monte Carlo methods, unfolding…
Classical Machine Learning
definition of machine learning, classification problem and Fisher discriminant, basic decision tree with math behind it, simple neural network with math behind it
Introduction to deep learning
simple forward networks, gradients and learning algorithms, generalization and overfitting
Advanced deep learning
Regularization techniques, Data preprocessing for deep learning, Specific architectures like Convolutional Neural Networks, common pitfalls and best practices, ...

Track 2: Machine Learning in Accelerator Technologies

Machine Learning for particle accelerators
- main use cases and applications

Bayesian Optimisation

Introduction to Reinforcement Learning

Advanced concepts for Reinforcement Learning

(4 hours of lectures and 3 hours of hands-on exercises)

Track 3: Machine Learning in Data Analysis

Introduction to Machine Learning for HEP, Anomaly detection and real time applications:
Intro on the evolution of ML use in HEP, data challenges in terms of
rate, complexity and required accuracy.
Real time applications with
focus in particular on anomaly detection (examples from trigger, but
it would be interesting to include the state of heart in terms of
data quality monitoring)

The data reconstruction step a pattern recognition problem:
- CNN, GNN, transformers architectures
- Examples from tracking and jet reconstruction/calorimetry

Generative Models for HEP:
- GANs, Flow, Diffusions
- Examples primarily from detector simulation and event generation

Systematics in ML:
- Experimental and Model uncertainties in ML
- Concepts of trustable and explainable AI

(4 hours of lectures and 3 hours of hands-on exercises)