IN2P3/IRFU Machine Learning workshop

Rapport sur les contributions

https://indico.in2p3.fr/e/ml-workshop-2022

ID de Contribution: **62** Type: **Non spécifié**

GNN for hadronic flow calibration in ATLAS

Hadronic jets are essential components of analysis at the LHC. Not only their Energy and mass needs to be precisely measured, their internal structure is also essential in order to distinguish signal jets from the common QCD initiated background jets. However jet constituents representing the energy flow insside jets do not have 1-to-1 correspondence with hadrons generated in simulations. In order to calibrate these constituents we consider them as nodes in a graph build from the jets they belong to and apply GNN techniques to derive a calibration for each of them. The presentation will details the methods, difficulties and status of this on-going work.

These details can include the GNN architecture, custom workflow (based on uproot, awkward, tensorflow/keras) and optimization approaches.

Auteur principal: DELSART, Pierre-Antoine (LPSC)

Orateur: DELSART, Pierre-Antoine (LPSC)

Classification de Session: Wed afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **63** Type: **Non spécifié**

Convolutional neural networks demultiplexing in large Micromegas detectors for muography purposes

lundi 26 septembre 2022 14:40 (20 minutes)

The muography project at CEA/IRFU uses high precision large gaseous detectors known as multiplexed Micromegas [1] which aim to reduce the cost of the electronic part by accumulating signal amplitudes together from 1037 strips into only 61 channels. Thanks to the properties of this genetic multiplexing [2], conventional algorithms may be and have been developed to recover estimated signals afterwards, and make it possible to compute the position of incident muons on the detectors. However, those algorithms shall anticipate a lot of different cases (channel cross-talk, cut or dead strips on the detector, large angle or simultaneous particles, ⋯) and therefore suffer from several biases that limit the muography and tomography quality. Besides, some demultiplexing algorithms have been able to achieve good performances but are not time-effective enough or rely on geometrical assumptions that do not apply on all events [3]. After the demultiplexing process, we reconstruct the tracks of particles crossing multiple detectors. Unfortunately, in some cases, a few wrong tracks may ruin the signal to noise ratio and make it impossible to run some analysis (like 3D reconstructions from outside the Khufu's Pyramid).

The difficulty to write a demultiplexing algorithm and the motivation to correct the known biases motivated us to consider machine learning techniques as an option. Thus, our goal is to develop a model capable of splitting the 61 multiplexed amplitudes into estimations of the unknown 1037 physical signals before the multiplexing. That model should be able to run on an embedded Linux on the muon telescope itself.

In this ongoing work we are studying convolutional neural network to benefit from the spatial properties of the filtering process with as few parameters as possible. In particular we construct multiple layers of one-dimensional convolutions [4] to process the multiplexed signal using the typical abstracted structures in the data. Moreover, we try to embed the knowledge of the genetic multiplexing architecture into the network using custom layers constraining the intermediate or final values. For the training of the model we mainly benefit of simulations to avoid the biases of previous demultiplexing algorithms that are mandatory to get real data. Therefore, part of our work focuses on finding a training process that uses a well-chosen share of standard and rare events, in order to have the best possible generalization on real data. The preliminary results already show a higher purity (~15% less unlikely tracks) but a smaller efficiency (~5% less tracks) than the previous solution. With our latest progresses we expect to be able to produce a significantly better demultiplexing process, which will make it possible to re-analyze without prior knowledge the data that was taken on ScanPyramids and on nuclear reactors at CEA.

[1] Giomataris, P. Rebourgeard, J. Robert, and G. Charpak, "Micromegas: A high-granularity position-sensitive gaseous detector for high particle-flux environments,"Nucl. Inst. and Meth. in Phys. Res. A 376, 29–35 (1996).

[2] S. Procureur, R. Dupré, and S. Aune, "Genetic multiplexing and first results with a 50x50 cm2 Micromegas,"Nucl. Inst. and Meth. in Phys. Res. A 729, 888 –894 (2013)

[3] B. Radics, G. Janka, D.A. Cooke, S. Procureur, P. Crivelli. "Double hit reconstruction in large area multiplexed detectors."Rev.Sci.Instrum., 2019, 90 (9), pp.093305.

[4] F. Chollet and others, "Keras", https://keras.io, 2015

Auteur principal: LEFEVRE, Baptiste (CEA/DRF/IRFU/DPhP)

Co-auteur: PROCUREUR, Sebastien (CEA-Saclay)

Orateur: LEFEVRE, Baptiste (CEA/DRF/IRFU/DPhP)

Classification de Session: Monday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **64** Type: **Non spécifié**

Machine Learning Algorithms for the Gamma Conversion Reconstruction in the ClearMind Project

lundi 26 septembre 2022 15:00 (20 minutes)

ClearMind project aims to develop the TOF PET detection module providing a high detection efficiency, coincidence resolving time $<$ 100 ps (FWHM), and spatial resolution in a few mm (FWHM). ClearMind project uses a large monolithic $PbWO_4$ crystal for the position-sensitive detector, microchannel-plate photomultiplier (MCP-PMT), and the bialkali photoelectric layer deposited on the crystal. The 511 keV gamma conversion produces both scintillating and Cherenkov photons, allowing the detector to have a good timing performance. We develop machine learning algorithms to reconstruct the 3D gamma conversion position in the crystal and compare them with a statistical method. To train the algorithms, we simulate the ClearMind detector in detail, including the gamma interaction in the medium, optical photon propagation, realistic simulation of the photocathode and the MCP-PMT, and the signal formation to generate the samples. In this study, the input variables are the parameters extracted from the readout signals, such as the charge, signal time, etc. We obtain the 2D spatial resolution of $<$ 5 mm (FWHM) and show a potential to reconstruct the depth-of-interaction (DOI) using machine learning algorithms. ClearMind collaboration is also developing the reconstruction algorithms using a full signal shape as the input, which is expected to perform better in DOI reconstruction and time resolution.

Auteur principal: SUNG, Chi-Hsun (IRFU)

Orateur: SUNG, Chi-Hsun (IRFU)

Classification de Session: Monday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **65** Type: **Non spécifié**

B decays reconstruction at Belle II using graph neural networks

mercredi 28 septembre 2022 14:00 (20 minutes)

The Belle II experiment has unique features that allow to study B meson decays with neutrinos in the final state. It is possible to deduce the presence of such particles from the energy-momentum imbalance obtained after reconstructing the companion B meson produced in the event. This task is complicated by the thousands of possible final states B mesons can decay into, and is currently performed at Belle II by the Full Event Interpretation (FEI) software, an algorithm based on Boosted Decision Trees and limited to specific, hard-coded decay processes.
In recent years, graph neural networks have proven to be very effective tools to describe relations in physical systems, with applications in a range of fields. Particle decays can be naturally represented in the form of rooted, acyclic tree graphs, with nodes corresponding to particles and edges representing the parent-child relations between them. In this work, we present a graph neural network approach to generically reconstruct B decays at Belle II by exploiting the information from the detected final state particles, without formulating any prior assumption about the nature of the decay. This task is performed by reconstructing the Lowest Common Ancestor matrix, a novel representation, equivalent to the adjacency matrix, containing information about the edge-level relations between particles. This approach allows reconstruction of the decay from the final state particles alone and preliminary results show that it outperforms the FEI by a factor of at least 3. In addition to edge-level information, the possibility of reconstructing node- or global-level attributes (such as the B momentum) is being explored.

Auteurs principaux: DUJANY, Giulio (CNRS - IPHC); CERASOLI, Jacopo (CNRS - IPHC)

Orateur: CERASOLI, Jacopo (CNRS - IPHC)

Classification de Session: Wed afternoon

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **66** Type: **Non spécifié**

Deep Learning Applied to Cherenkov Telescope Array Images

mercredi 28 septembre 2022 09:20 (20 minutes)

Gamma-ray astronomy is a field of physics that studies astrophysics sources of high-energy photons. These uncharged particles travel in straight lines and are not deviated by magnetic fields along their journey to Earth, making possible the track of their origins. Once they interact with the atmosphere, they produce particle showers, emitting lights through the so-called Cherenkov process, which will be captured by the optical telescopes called Imaging Atmospheric Cherenkov Telescopes (IACT). Their analysis consists in solving an inverse problem : the determination of the energy and the direction of arrival of the incoming photons given the telescope images. Through these studies, scientists may understand for instance the star birth process, the nature of dark matter, or even the evolution of galaxies. But this is a complicated task because other cosmic particles produce the same kind of showers, and photons are highly underrepresented. Fortunately, deep learning has been a great tool in solving many computer vision tasks. As a result, the GammaLearn project is born and aims to integrate deep learning approaches in the context of gamma-ray astronomy. However, the training procedure in our case implies the need of labelled data, which is unobtainable. Therefore, Monte Carlo simulations are used for the training, but the performance is degraded when applied on real data due to domain shifts between the two distributions. Fortunately, domain adaptation technic can be applied to this specific problem to improve the learning transfer from simulated data to observed data. In more details, two methods have currently been integrated into the GammaLearn workflow and preliminary results have shown encouraging ameliorations.

Auteur principal: Dr VUILLAUME, Thomas (LAPP, CNRS)

Orateur: DELL'AIERA, Michaël (LAPP, CNRS)

Classification de Session: Wed morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **67** Type: **Non spécifié**

Echo State Networks for Dynamic Aperture prediction

lundi 26 septembre 2022 16:10 (20 minutes)

The Reservoir Computing Echo State Network (ESN) are a class of recurrent neural networks that are computationally effective, since they avoid back-propagation and they require cross-validation only.
They have been proven to be universal approximant of dynamical systems.
We present the performance reached by ESN to predict the long term behavior of the extent of the phase space region in which the motion of charged particle in hadron storage rings is bounded (called dynamic aperture). In particular, we show that ESN complemented with analytical scaling laws based on the stability-time estimate of Nekhoroshev theorem for Hamiltonian system, are able to predict effectively the time evolution of the dynamic aperture, thus providing an efficient and fast surrogate model.

Auteurs principaux: DALENA, Barbara (IRFU); Prof. BONAVENTURA, Luca (Politecnico di Milano); Dr GIOVANNOZZI, Massimo (CERN); CASANOVA, Maxime

Orateur: DALENA, Barbara (IRFU)

Classification de Session: Monday afternoon

Classification de thématique: 8 ML for particle accelerators (only if does not fit in Tracks above)

ID de Contribution: **68** Type: **Non spécifié**

Optimized Reconstruction of the Position of Interaction in High-Performances γ-Cameras

mardi 27 septembre 2022 10:00 (20 minutes)

Introduction
Targeted radionuclide therapy is one of the most widespread treatment modality for benign and malignant thyroid diseases. In order to maximize the therapeutic effects on the target tissues while minimizing the toxicity for organs-at-risk with adapted dose, individually defined for each patient taking account their own biokinetics, dedicated γ-imaging devices are required. They must be optimized for high energy γ-rays and high photon fluences and avalaible for repeated measurements at specific times before and after treatment administration. In order to overcome these shortcomings, our objective is to develop a portable high-resolution gamma camera specifically optimized for dose quantification at the patient's bedside during the treatment of thyroid diseases with ^{131}I. After a first prototype of gamma camera with a 5×5~cm^2 field of view (FoV) succesfully developed with very promising results~\cite{carlotta}, we are currently developing a fully operational clinical version of the mobile gamma camera with a 10×10~cm^2 FoV suited to the size of the thyroid, millimetric spatial performance and increased counting capabilities (200 kcps). Such spatial performances are obtained thanks to the use monolithic inorganic scintillators and pixelated photodetectors. It however requires efficient reconstruction methods of the position of interaction of the γ-rays in the medium. This is usually performed either by interpolation methods based on reference data or on a light distribution analytical model for each camera to be fit on the data. In both cases this requires strong computation, limiting its use for real time clinical applications. Neural networks propose an interesting alternative as they could provide both an efficient method for accurate reconstruction of γ-rays based on a reference dataset for training, prior its clinical use. The network can then be used at high frequency for real time imaging as the reconstruction for each γ-ray would be reduced to a simple tensor multiplication. We propose here a comparison of performances obtained with an interpolated fitting method and a neural network both based on experimental data for training and validation.

Material and Methods
The photodetection module of the mobile gamma camera is composed of a 10×10~cm^2 and 1 cm thick monolithic $CeBr_3$ scintillator with reflective optical coatings. It is optically coupled to a 4×4 Hamamatsu S13361-6050 arrays of 4×4 silicon photomultipliers (SiPMs). The pixels have an effective sensitive area of 6×6 mm^2 and a micro-cell size of 50×50 μm^2. The signals produced by the SiPMs are shaped and digitized by a commercial front-end electronics manufactured by the PETSys company. It is composed of four TOFPET 2B ASIC with 64 analog reading channels. The spatial performance were evaluated by using a ^{133}Ba source collimated by a tungsten collimator with a 0.5~m diameter hole. Thermal noise events (11 kcps for the operative bias and individual trigger threshold used) are completely suppressed by an internal hardware trigger (10ns coincidence window) which operates between two regions of the photodetector defined as a checkerboard where each square corresponds to a 4×4 SiPM array. The non uniformity of the photodetector light response was evaluated and corrected by irradiating the field of view with a pulsed LED source. The relative standard deviation of the light responses over the 256 pixels before and after correction are 12.8\% and 0.96\%, respectively. A scan of the whole FoV was performed with a 1~mm step, recording, for each position, about 2000 scintillation events. Half of these events were used as a reference dataset for training while the other half were used for performances evaluation. Additionally a flood-field uniformity acquisition was carried out with the same source, set at about 50~cm of the scintillator and with no collimator. Each scintillation event produce a light pulse within the monolithic scintillator that propagates – possibly after some reflections – to the SiPM array leading to a 16×16 frame. As the intensities in the pixels of the frame contains some information about the position of interaction of the incident gamma-ray, it is therefore possible to

reconstruct the later *a posteriori* using dedicated algorithm. Two methods of reconstruction of the position of interaction limited in the (x, y) plane were tested: a least-square fitting method and a neural network. As the response function of each pixel of the camera is unknown, preventing the use of analytical models for fitting, the discrete light response functions of the pixels were determined by average the frames of the reference scan dataset. The other frames were then fit with standard least-square minimizing (Levenberg-Marquardt optimization) an objective function calculated, at each step, by bivariate spline interpolation. The neural network, on the other hand, were performed using Keras (Tensorflow) Python library, and using the *Deep Residual Convolution* architecture. A *Deep Residual Convolutional* block is composed of an input image, directed on one side through two classical convolutional layers, and on the other side through an identity shortcut. The output of these two branches are then summed and activated by a ReLU (Rectified Linear Unit) activation function. The network loss optimization is achieved thanks to the Adam algorithm. Our neural network uses two of these so called *Deep Residual Convolutional* blocks and is trained thanks to the aforementioned reference dataset, using the 256 pixels frames as input and the mechanical position of the source as output. For both reconstruction methods, the performances are evaluated, on the one hand by reconstruction of the second half of the scan dataset (not used for training), yielding a measurement of the spatial resolution by fit of a 2 dimensions gaussian on the reconstructed position of all the events for each scan position as well as a measurement of the bias by comparing the reconstructed position to the actual mechanical positions of the scan. On the other hand the uniformity of the spatial response was obtained by reconstruction of the positions of interaction of the flood-field data.

Results

The fit method yields a average intrinsic spatial resolution in the central FoV (75\% linear of the total FoV), of 1.33 ± 0.08~mm FWHM with a bias of 0.05 ± 0.03~mm and an integral and differential uniformity of respectively 10.19\% and 8.90\%. It however, strongly deteriorate towards the edges of the FoV, reaching an average spatial resolution of 9.13~mm FWHM with a bias of 0.52 ± 0.82~mm and an integral uniformity of 11.44\% and a differential uniformity of 18.17\%. On the other hand the intrinsic performances with neural network are better with a spatial resolution in the central FoV of 1.09 ± 0.06~mm FWHM but but with a bias of 0.09 ± 0.05~mm and an integral and differentials uniformity of respectively 4.95\% and 8.06\%, while less degrading near the edges with a spatial resolution of 6.74~mm FWHM and a bias of 0.42 ± 0.55~mm. It is however worse in terms of uniformity with 43.24\% and 34.32\% for the integral and the differential uniformity respectively.

Auteurs principaux: MENARD, Laurent (IJCLab - Pôle Physique Santé); Dr VERDIER, Marc-Antoine (IJCLab - Université de Paris); BOSSIS, Théo (IJCLab/CNRS)

Co-auteurs: M. BROGGIO, David (IRSN, LEDI, Fontenay-aux-Roses, France); BOUVET, Françoise (IJCLab); M. CASELLES, Olivier (IUCTO, ICR, Toulouse, France); M. ZERDOUD, Slimane (IUCTO, ICR, Toulouse, France); Mme LAMART, Stéphanie (IRSN, LEDI, Fontenay-aux-Roses, France); Mme BEAUMONT, Tiffany (IRSN, LEDI, Fontenay-aux-Roses, France); M. PINOT, laurent (cnrs)

Orateur: BOSSIS, Théo (IJCLab/CNRS)

Classification de Session: Tuesday morning

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **69** Type: **Non spécifié**

An EIM-based compression-extrapolation tool for efficient treatment of homogenized cross-section data

mardi 27 septembre 2022 09:00 (20 minutes)

Nuclear reactor simulators implementing the widespread two-steps deterministic calculation scheme tend to produce a large volume of intermediate data at the interface of their two subcodes –up to dozens or even hundred of gigabytes –which can be so cumbersome that it hinders the global performance of the code. The vast majority of this data consists of "few-groups homogenized cross-sections", nuclear quantities stored in the form of tabulated mutivariate functions which can be precomputed to a large extent.

It has been noticed in the past that few-groups homogenized cross-sections are highly redundant - that is, they exhibit strong correlations, which paves the way for the use of compression techniques. We here leverage this idea by introducing a new coupled compression/surrogate modeling tool based on the Empirical Inter-
polation Method, an algorithm originally developed in the framework of partial differential equations. This EIM-compression method is based on the infinite norm, and proceeds in a greedy manner by iteratively trying to approximate the data and incorporating the chunks of information which cause the largest error. In the process, it generates a vector basis and a set of interpolation points, which provide an elementary surrogate model that can be used to approximate future data from little information. The algorithm is also very suitable for parallelization and out-of-core computation (processing of data too large for the computer RAM) and very easy to apprehend and implement.

This methodology enables us to both efficiently compress cross-sections and spare a large fraction of the required physics calculations. We investigate its performance on heavy realistic nuclear data replicating a notorious benchmark. Compression loss, memory savings and speed are analyzed both from a data-centric point of view in the perspective of applications in neutronics, and by comparison with an existing and widely-used method –stochastic truncated SVD –to assess mathematical efficiency. We discuss the usage of our surrogate model and its sensitivity to the choice of the training set. The method is shown to be competitive in terms of accuracy and speed, provide important memory savings and spare a large amount of physics code computation.

Auteur principal: TRUFFINET, Olivier

Co-auteurs: Dr BOURIQUET, Bertrand; Dr ARGAUD, Jean-Philippe; Dr AMMAR, Karim; M. GÉRARD CASTAING, Nicolas

Orateur: TRUFFINET, Olivier

Classification de Session: Tuesday morning

Classification de thématique: 3 ML for simulation and surrogate model : Application of Machine Learning to simulation or other cases where it is deemed to replace an existing complex model

ID de Contribution: **71** Type: **Non spécifié**

Data/MC adaptation with adversarial training in KM3NeT

mercredi 28 septembre 2022 09:40 (20 minutes)

Data and MC represent different domains. Supervised learning in MC needs to be transferred to the real data domain and MC mismodelling can reduce the performance of the transferred models. In this work we are implementing the Domain Adversarial Neural Network (DANN) concept to the standard Graph Neural Network (GNN) classification and regression tasks in the KM3NeT/ORCA experiment. We will present the current status and prospects for the project.

Auteurs principaux: COELHO, Joao (APC / CNRS); PENA MARTINEZ, Santiago (Aix-Marseille Université); LIANG, Shen

Orateur: COELHO, Joao (APC / CNRS)

Classification de Session: Wed morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **72** Type: **Non spécifié**

Multi-objective optimization for the CMS High Granularity Calorimeter Level 1 trigger

mardi 27 septembre 2022 16:50 (20 minutes)

The CMS collaboration has chosen a novel High-Granularity Calorimeter (HGCAL) for the endcap regions as part of its planned upgrade for the high luminosity LHC. The high granularity of the detector is crucial for disentangling showers overlapped with high levels of pileup events (140 or more per bunch crossing at HL-LHC). But the reconstruction of the complex events and rejection of background pose significant challenges, particularly for the Level 1 (L1) trigger, where the processing resources and latency are tightly constrained. It is therefore planned to use Machine Learning (ML) models for this task, in particular for the identification of electromagnetic and hadronic showers using the 3D shape of the energy deposits. The 3D shape of a shower is encoded in the form of shape variables computed in the HGCAL trigger primitives generation (TPG) system and sent to the central L1 trigger where they are used as inputs by classification models. The choice of this set of variables is crucial and must take into account their discrimination power, but also the limited bandwidth between the HGCAL TPG and the central L1T and the hardware resources needed to implement the classifiers. In order to find the best compromise, a multi-objective optimization technique based on genetic algorithms is used to optimize together the classification performance, the number of bits required to encode the shape variables, and the classification model complexity. The results of this optimization, and in particular the balance between performance and hardware complexity, will be discussed in this presentation.

Auteur principal: HAKIMI, Alexandre (LLR, école polytechnique/CNRS)

Co-auteur: SAUVAN, Jean-Baptiste (LLR Ecole Polytechnique)

Orateur: HAKIMI, Alexandre (LLR, école polytechnique/CNRS)

Classification de Session: Tuesday afternoon

Classification de thématique: 4 Fast ML : Application of Machine Learning to DAQ/Trigger/Real Time Analysis

ID de Contribution: **73** Type: **Non spécifié**

IN2P3 School of Statistics

mardi 27 septembre 2022 14:20 (20 minutes)

The 2022 edition of the School of Statistics SOS2022 was held in Carry-le-Rouet (13) from 16 to 20 May 2022. The school targets PhD students, post-docs and junior/senior scientists (researchers, engineers) wishing to strengthen their knowledge or discover new methods in statistical analysis applied to particle and astroparticle physics, cosmology and nuclear physics.

The programme covers from fundamental concepts to advanced topics. A special focus is put on machine learning techniques and tools. A significant amount of time is dedicated to hands-on sessions to introduce advanced tools (scipy, scikit-learn, keras, Tensorflow, all with Jupyter notebook) and their applications to our domain.

All slides, notebooks and video recordings of the sessions are available at:
https://indico.in2p3.fr/e/SOS2022

The next edition is expected for spring 2024.

Auteur principal: COADOU, Yann (CPPM, Aix-Marseille Université, CNRS/IN2P3)

Orateur: COADOU, Yann (CPPM, Aix-Marseille Université, CNRS/IN2P3)

Classification de Session: Tuesday afternoon

Classification de thématique: 6 ML training, courses, tutorial, open datasets and challenges

ID de Contribution: **75** Type: **Non spécifié**

Classification of Brain tumour tissues in Human Patients using Machine Learning

mardi 27 septembre 2022 09:40 (20 minutes)

Delineating brain tumor margins as accurately as possible is a challenge faced by the neurosurgeon during tumor resections. The extent of resection is correlated with the survival rate of the patient while preserving healthy surrounding tissues is necessary. Real-time analysis of the endogenous fluorescence signal of brain tissues is a promising technique to answer this problem. For this purpose, a miniaturized multimodal non-linear endomicroscope is currently under development. The development of this tool requires in parallel the construction of a tissue database that includes the different imaging modalities that will be integrated into the endomicroscope. The database contains optical signatures from different samples of brain tissues, either healthy or tumoral, excited at different wavelengths. The collected data include spectroscopy measurements, fluorescence lifetime and auto-fluorescence images.
We will present two different studies carried out on these data.
The first one is based on spectroscopy data. We used Decision Tree based models and relative models to discriminate healthy from tumor tissues using different quantitative parameters computed from each spectrum. Two analogous studies will be presented, one in the visible excitation domain using 375 and 405 nm and the other in the Deep Ultra-Violet using 275 nm.
The second study is based on auto-fluorescence images. These images represent the response of endogenous fluorescence under two-photon excitation and the generation of the second harmonic in the near infrared excitation domain. In this study, we present the classification of those images into 6 classes (5 different pathologies and 1 control) using a convolution network. We show that the use of transfer learning and data augmentation methods significantly improve the results of the classification.

Auteur principal: BOUVET, Françoise (IJCLab)

Orateur: BOUVET, Françoise (IJCLab)

Classification de Session: Tuesday morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **76** Type: **Non spécifié**

GNN for hadronic flow calibration in ATLAS

mardi 27 septembre 2022 16:10 (20 minutes)

Hadronic jets are essential components of analysis at the LHC. Not only their Energy and mass needs to be precisely measured, their internal structure is also essential in order to distinguish signal jets from the common QCD initiated background jets. However jet constituents representing the energy flow insside jets do not have 1-to-1 correspondence with hadrons generated in simulations. In order to calibrate these constituents we consider them as nodes in a graph build from the jets they belong. We apply GNN techniques to derive a calibration for each of the nodes (constituents) using graph (jets) level constraints. The presentation will details the methods, difficulties and status of this on-going work.
These details can include the GNN architecture, custom workflow (based on uproot, awkward, tensorflow/keras) and optimization approaches.

Auteurs principaux: PEREIRA PEIXOTO, Ana Paula (Laboratoire de Physique Subatomique et de Cosmologie de Grenoble (LPSC/CNRS)); DELSART, Pierre-Antoine (LPSC)

Orateur: PEREIRA PEIXOTO, Ana Paula (Laboratoire de Physique Subatomique et de Cosmologie de Grenoble (LPSC/CNRS))

Classification de Session: Tuesday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **77** Type: **Non spécifié**

Calibration and evaluation of an unsupervised machine learning algorithm for β+ imaging using an intracerebral micro probe

mardi 27 septembre 2022 09:20 (20 minutes)

Purpose: The correlation of molecular neuroimaging and behavior studies in the preclinical field is of major interest to unlock progress in the understanding of brain processes and assess the validity of preclinical studies in drug development. However, fully achieving such ambition requires being able to perform molecular images of awake and freely moving animals whereas currently, most of the preclinical imaging procedures are performed on anesthetized animals. To achieve such a combination, MAPSSIC, a pixelated intracerebral probe based on the CMOS technology, has been developed in order to be implanted on awake freely moving rats. This probe is set to image β+ radioisotopes. Thanks to its in situ position, the probe is able to directly detect positrons unlike PET scans that use the coincidence gammas from annihilation as a relevant signal. The aim of this study is to asses the ability of an unsupervised Machine Learning algorithm to provide tangible information on the actual interaction processes in a sensor in terms of identification and localization of interaction events in the probe images.
Materials and methods: The probe relies on MAPS (Monolithic Active Pixel Sensors) 6400 µm x 610 µm MAPS containing 2048 (16 x 128) pixels including a one bit digitizer. The thickness of the sensible area is set to a compromise to ensure a high sensitivity to positrons and a good transparency to γ-rays, ensuring a very local information. When a positron interacts within the sensitive area of the sensor, this usually results in a cluster of activated pixels due to the ionizing track of β-particles in silicon and charge sharing between pixels. As the readout is based on a rolling shutter, pile-up occurs by the accumulation of counts in one or several pixels that have already been activated after the last read-out. At low activities, a simple cluster segmentation can quite easily allow to determine the number and position of each cluster and therefore the detected activity in a frame. Higher activities require, however, alternative pixel clustering in order to avoid wrong segmentation that leads to a loss of sensitivity and bias in event localization. In order to overcome segmentation issues due to pileup in sensors images (frames), the Affinity propagation (AP) clustering algorithm based on an iterative measure of similarity between points in a given data set has been utilized. Each cluster determined by the AP algorithm is composed by one ”exemplar”(point that represents the best a cluster distribution) and zero to several other data points. The key parameter in the AP algorithm is the preference, which controls how many exemplars are used at the initialization and thus, influences the resulting cluster number in the output. Frames from experimental measurements obtained with a sensor and a 18F source and containing only one cluster have been used to randomly generate 1,000,000 frames containing 1 to 100 clusters each. This process has been done twice in order to get 2 sets of data: a calibration data set and a validation one. The calibration data set was used to determine the optimal preference value used to correctly identify the clusters in each frame. The preference value has been determined for frames containing from 1 to 100 clusters. The affinity propagation algorithm has then been applied to the validation data set using the previously determined preferences values and after a first rough estimation of the cluster number in each frame.
Results: The output were analyzed both in quantitative and spatial terms. The results show that the affinity propagation is well suited for the clustering of the MAPSSIC microprobe, up to about 100 clusters per frames. It also has comparable or better quantitative results to cluster estimations

using the mean number of activated pixels by clusters. On top of that, the latter does not allow for spatial localization of each event unlike the AP algorithm. The calculation time varies from few milliseconds to 0.5 seconds and appears to be dependent to the number of activated pixel in the frame. The spatial analysis shows a great localization accuracy using the affinity propagation algorithm. For more than 95% of the clusters, the spatial error on the cluster's barycenter is basically equal or smaller than the pixel dimensions. The affinity propagation algorithm proves to be a very strong tool in image processing of a β-sensitive intracerebral microprobe such as MAPSSIC.

Auteurs principaux: EL KETARA, Samir (IJCLab, Université Paris-Saclay); LANIECE, philippe (IMNC); Dr VERDIER, Marc-Antoine (IJCLab - Université de Paris)

Co-auteurs: Dr AMMOUR, Luis (Nantes Université, CHU Nantes, F-44000 Nantes, France); BAUDOT, Jerome (IPHC); Dr BOUVARD, Sandrine (CERMEP-Imagerie du vivant, Universit́e Claude Bernard Lyon 1, CNRS, INSERM, Hospices Civils de Lyon, Lyon, France); DUPONT, Mathieu (Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France); GENSOLEN, Fabrice (CPPM, Aix Marseille Univ, CNRS/IN2P3, Marseille, France); KACHEL, Maciej (IPHC C4Pi); LAURENCE, jérôme (Mécanique); MOREL, Christian (Aix-Marseille Univ, CNRS/IN2P3, CPPM); M. PANGAUD, Patrick (Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France); Prof. ZIMMER, Luc (CERMEP-Imagerie du vivant, Universit́e Claude Bernard Lyon 1, CNRS, INSERM, Hospices Civils de Lyon, Lyon, France)

Orateur: EL KETARA, Samir (IJCLab, Université Paris-Saclay)

Classification de Session: Tuesday morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **78** Type: **Non spécifié**

Multiview Symbolic Regression

mardi 27 septembre 2022 16:30 (20 minutes)

Symbolic Regression is a data-driven method that searches the space of mathematical equations with the goal of finding the best analytical representation of a given dataset. It is a very powerful tool, which enables the emergence of underlying behavior governing the data generation process. Furthermore, in the case of physical equations, obtaining an analytical form adds a layer of interpretability to the answer which might highlight interesting physical properties.
However equations built with traditional symbolic regression approaches are limited to describing one particular event at a time. That is, if a given parametric equation was at the origin of two datasets produced using two sets of parameters, the method would output two particular solutions, with specific parameter values for each event, instead of finding a common parametric equation. In fact there are many real world applications where we want to propose a formula for a family of events which may share the same functional shape, but with different numerical parameters
In this work we propose a simple adaptation of the Symbolic Regression method that is capable of recovering a common parametric equation hidden behind multiple examples generated using different parameter values. We call this approach Multiview Symbolic Regression. We demonstrate how we can reconstruct famous physical equations from the seminal Feynman Lectures on Physics (S.-M. Udrescu et al., 2020). Additionally we explore possible applications in the domain of astronomy for light curves modeling. Building equations to describe astrophysical object behaviors can lead to better flux prediction as well as new feature extraction for future machine learning applications.

Auteur principal: RUSSEIL, Etienne (Université Clermont Auvergne, LPC, Clermont Ferrand, France)

Co-auteurs: Dr ISHIDA, Emille (CNRS/LPC-Clermont); GANGLER, Emmanuel (LPC); Dr OLIVETTI DE FRANÇA, Fabricio (Center for Mathematics, Computation and Cognition (CMCC), Heuristics, Analysis and Learning Laboratory (HAL), Federal University of ABC, Santo Andre, Brazil); MALANCHEV, Konstantin (University of Illinois at Urbana-Champaign)

Orateur: RUSSEIL, Etienne (Université Clermont Auvergne, LPC, Clermont Ferrand, France)

Classification de Session: Tuesday afternoon

Classification de thématique: 7 ML for phenomenology and theory (only if does not fit in Tracks above)

ID de Contribution: **79** Type: **Non spécifié**

Auto-tuning of the material mapping with the ACTS track reconstruction suite

mercredi 28 septembre 2022 11:10 (20 minutes)

The reconstruction of particle trajectories is a key challenge of particle physics experiments as it directly impacts particle reconstruction and physics performances. To reconstruct these trajectories, different reconstruction algorithms are used sequentially. Each of these algorithms use many configuration parameters that need to be fine-tuned to properly account for the detector/experimental setup, the available CPU budget and the desired physics performance. Until now, these parameters had to be optimised by human experts which is inefficient and raises issues for the long term maintainability of such algorithms. Previous experiences with using machine learning for particle reconstruction (such as the TrackML challenge) have shown that they can be easily adapted to different experiments by learning directly from the data. We propose to bring the same approach to the classic track reconstruction algorithms by connecting them to an agent driven optimiser which will allow us to find the best set of input parameters using an iterative tuning approach. We demonstrated this approach on the generation of simplified material map used for trajectory reconstruction within A Common Tracking Software (ACTS) framework using the Open Data Detector (ODD).

Co-auteur: GRASLAND, Hadrien (IJCLab)

Orateur: ALLAIRE, Corentin (IJCLab)

Classification de Session: Wed morning

Classification de thématique: 9 Other

ID de Contribution: **80** Type: **Non spécifié**

Maximum-A-posteriori estimate with Deep generative NEtworks for Source Separation (MADNESS)

lundi 26 septembre 2022 14:00 (20 minutes)

The next generation of astronomical surveys will collect massive amounts of data. It will present challenges not only because of the sheer volume of data but also because of its complexity. In the Legacy Survey of Space and Time (LSST) at the Vera Rubin Observatory, more than 60% of objects along the line of sight are expected to overlap in the images. Classical methods for solving the inverse problem of source separation, so-called "deblending", either fail to capture the diverse morphologies of galaxies or are too slow to analyze billions of galaxies. To overcome these challenges, we propose a deep learning-based approach to deal with the size and complexity of the data.

Our algorithm called MADNESS deblends galaxies from a field by finding the Maximum-A-posteriori solution parameterized by latent space representation of galaxies generated with deep generative models. We first train a Variational Autoencoder (VAE) as a generative model and then model the underlying latent space distribution so that can it be sampled to simulate galaxies. To deblend galaxies, we perform gradient descent in the latent space to find the MAP estimate.

In my talk, I will outline the methodology of our algorithm, evaluate its performance, and compare it against state-of-the-art techniques using flux reconstruction as a metric.

Auteur principal: BISWAS, Biswajit (APC)

Co-auteurs: BOUCAUD, Alexandre (APC / IN2P3); GUINOT, Axel (APC/IN2P3); ROUCELLE, Cécile (APC); AUBOURG, Eric (APC); Dr LAO, Junpeng (Google Research, Zurich)

Orateur: BISWAS, Biswajit (APC)

Classification de Session: Monday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **81** Type: **Non spécifié**

The ELAsTiCC data challenge: preparing the Fink broker for LSST

mercredi 28 septembre 2022 10:00 (20 minutes)

Fink is a community alert broker specifically designed to operate under the extreme data volume and complexity of the upcoming Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST). It is a French-led international collaboration whose task is to select, add value and redistribute transient alerts to the astronomical community during the 10 years of LSST. The system is completely operational and currently processes alerts from the Zwicky Transient Facility (ZTF), considered a precursor of LSST. Nevertheless, there are still important differences between the two surveys in terms of data format and complexity. In order to simulate the interaction between broker systems and an LSST-like alert stream, the Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC) is being organized. In this talk, I will describe the challenge, its goals and the efforts by different groups within Fink to develop machine learning classification algorithms accurate and scalable to large data volumes. I will also describe how this experience helped shape our confidence in the Fink system and the resilience of its international community, which has developed modules/filters to search for supernovae, fast transients, microlensing, AGNs, anomaly detection and multi-class deep learning classifiers.

Auteurs principaux: ISHIDA, Emille (CNRS/LPC-Clermont); MOLLER, Anais (Swinburne University); Dr PELOTON, Julien (CNRS-IJCLab)

Orateur: ISHIDA, Emille (CNRS/LPC-Clermont)

Classification de Session: Wed morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **83** Type: **Non spécifié**

Deep learning for slit-less Spectroscopic Redshift survey Simulator (DISPERS)

mercredi 28 septembre 2022 09:00 (20 minutes)

Since the discovery of the acceleration of the expansion of the Universe, the concordence model describes the Universe as spatially flat curvature with about 5 % of baryonic matter, 26 % of cold dark matter and 68 % of Dark Energy. However, understanding the nature of both, the dark matter and dark energy components remains unknown this puzzle is one of the greatest challenges in contemporary physics. The forthcoming massive wide and deep galaxy surveys which are designed to map the observable Universe in large redshift range will put stringent constraints on theories that describe dark energy, dark matter, as well as modified general relativity.
In order to prepare those future mission as well as to validate pipelines, from the data reduction to the cosmological analyses, simulations of realistic sky images are of fundamental importance. However, to fullfill their purposes, massive number of sky images need to be simulated under different conditions (different instrument parameters, different cosmologies), consuming a massive amount of computation power, difficult to achieve on reasonable timescale.
Our proposal aims at taking advantage of the latest machine learning technics to develop a sky image simulator relying on physical and realistic instrument response. Indeed, the uses of machine learning methods could greatly enhance computing capability without loosing on precision. It also bring the possibility for recurrent approaches that may improve instrument calibration and subsequently cosmological parameters inference. This project focus on simulation of sky images of slit-less spectroscopy observation for the NISP instrument of the future Euclid space mission. However it is an innovative project that could bring new way to simulate galaxy redshift survey as, to our knowledge, the uses of machine learning technics for simulating slit-less spectroscopic dataset has never been done.

Auteurs principaux: ZOUBIAN, Julien (Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France); GILLARD, William (CPPM - Université Aix-Marseille)

Orateur: ZOUBIAN, Julien (Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France)

Classification de Session: Wed morning

Classification de thématique: 3 ML for simulation and surrogate model : Application of Machine Learning to simulation or other cases where it is deemed to replace an existing complex model

ID de Contribution: **84** Type: **Non spécifié**

Gamma-ray spectrometry of fission fragments: ML analysis of multi-dimensional spectra

mercredi 28 septembre 2022 14:40 (20 minutes)

The analysis of gamma radiation emitted by fission fragments has become an essential tool for studying the nuclear fission process. It allows to probe the intrinsic properties of the fragments or to explore effects little studied experimentally such as the sharing of excitation energy between fragments at nuclear fission. It also provides nuclear data directly useful for reactor simulation.
The analysis of experimental fission gamma-ray data by traditional techniques is time consuming and complex. The processing of the experimental data is done in two steps. The
first step aims at reducing the amount of measured data into two or three dimensional distributions of gammas emitted in coincidence. The second step, the actual analysis work, consists in identifying or finding the gamma rays emitted by the different fragments in these 2D or 3D distributions and extracting their intensity.
The difficulty of this last task is related to several factors. The distributions are filled with thousands of peaks of very variable amplitude and often overlapping, because the fission generates a few hundred different fragments and each fragment emits several gamma rays
during its de-excitation. The shape of the peaks is quasi-Gaussian but their width depends on the energy and the peaks have low energy tails which is superimposed on a rather important background noise.
Several points may be unlocked if prescriptive algorithms were developed using machine learning to assist the analysis and replace manual operations. We will present the project and the ML techniques we would like to apply.

Auteurs principaux: BALLU, Mattéo; MATERNA, Thomas (CEA DRF IRFU)

Orateur: BALLU, Mattéo

Classification de Session: Wed afternoon

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **85** Type: **Non spécifié**

Reconstruction of electromagnetic showers in calorimeters using Deep Learning

mardi 27 septembre 2022 15:00 (20 minutes)

Machine Learning (ML) algorithms are currently a leading choice for Data Analysis applications in various fields: from industry to science and medicine. Following the general trend, different ML methods (Boosted Decision Trees, Neural Networks) have already been successfully used for data reconstruction and analysis in the CMS experiment. More sophisticated algorithms are becoming available, which may bring advantages to the reconstruction techniques using more and more low-level information.

In this talk, I will describe the application of the state-of-the-art neural network architecture for data reconstruction in the electromagnetic calorimeter (ECAL) of CMS. While traversing the ECAL, electrons and photons will leave energy deposits in the crystals of the calorimeter. These deposits have to be combined together to form a cluster, from which the energy and impact position of the initial particle can be reconstructed. Currently, a traditional algorithm (based on Gaussian-mixture model) is used for this task.

We are developing a new model based on the convolutional neural network and graph neural network for the reconstruction in ECAL. The network results show significant improvement both in energy and coordinate resolution for photons in comparison with the traditional algorithm. Moreover, one of the main advantages of the network is the ability to distinguish between multiple close-by clusters. This plays a crucial role in discriminating between high-energy pions (pi0-> gg, creating two overlapping clusters in the ECAL) and standalone photons.

Auteur principal: SIMKINA, Polina (CEA-Saclay)

Co-auteurs: COUDERC, Fabrice (CEA); MALCLES, Julie (IRFU, CEA-Saclay); SAHIN, Mehmet Ozgur (CEA-Saclay)

Orateur: SIMKINA, Polina (CEA-Saclay)

Classification de Session: Tuesday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **86** Type: **Non spécifié**

Missing data reconstruction using ML techniques in the gaseous TPC PandaX-III experiment

mardi 27 septembre 2022 15:20 (20 minutes)

The PandaX-III experiment, developed to search for the Neutrinoless Double-beta decay (NLDBD), is based on a Time Projection Chamber (TPC) detector of cylindrical shape with a height of 120.0 cm, a diameter of 160.0 cm. It is filled with 10 bar gaseous Xe-136, and the readout plane is made out of 52 Micromegas modules 20 by 20 cm in size. Each Micromegas module is constructed with 64 by 64 readout channels in X and Y directions. Usually, Micromegas technology is used for tracking purposes; however, in the PandaX-III experiment, they are also used to measure deposited energy from the ionizing particles inside the gas. The rare double-beta decays of the Xe-136 nuclei generate two low-energy electrons, which produce ionization in the gas volume along their trajectories. Due to the electric field between the cathode and anode (the readout plane), electrons from the ionization process drift towards the anode and are detected by the Micromegas readout strips. Therefore, the output of the detector is represented by the total detected energy of the decay event plus XZ and YZ projections of the initial decay event track, used for background discrimination. The NLDBD search requires achieving excellent energy resolution in order to discriminate signal from backgrounds. For that, the PandaX-III experiment aims to reach a resolution better than 3% FWHM at the double beta decay peak of the Xe-136 at 2.5MeV.
However, due to the physical damage, shortcuts on the readout strips, dark current, etc., some of the readout channels could be disconnected; thus, the signal from them would be missed, giving losses on the energy measurements and the track reconstruction. In addition to that, the signal gain could be inhomogeneous on the surface of the Micromegas module, which results in a degradation of the energy reconstruction as well. To improve the quality of the measurement, data should be corrected from missing channels and inhomogeneities. That is why I am currently studying machine learning (ML) techniques to reconstruct the missing information.
In my talk, I will first present the PandaX-III experiment and its problematics and then the ML studies. In particular, the usage of the Convolutional Neural Network on the event electronics signals to reconstruct event energy from incomplete and biased event data will be described, and preliminary results will be presented.

Auteur principal: LOBASENKO, Andrii (CEA-Saclay/IRFU/DPhN)

Orateur: LOBASENKO, Andrii (CEA-Saclay/IRFU/DPhN)

Classification de Session: Tuesday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **87** Type: **Non spécifié**

LinacNet: a new architecture for linear accelerator surrogate model

lundi 26 septembre 2022 16:30 (20 minutes)

Accelerator physics simulations are a powerful tool for optimizing particle accelerator experiments.
They give accurate predictions of the behavior of the beam along the machine according to the values of the input parameters of the machine.
However, simulations can be lengthy, and this computation time can limit their potential application.
Machine Learning can be used to learn fast-executing surrogate models of the simulation program.
Once the model is learned, multiple experiments can be performed in parallel, allowing fast optimization of the input parameters.

This work proposes a new neural network architecture that incorporates some physical constraints of a linear accelerator.
The novelty of this architecture resides in its modularity and the representation of a beam for learning purposes.
Each module represents the propagation of a beam between two diagnostic stations and receives in input only the relevant input parameters for this section and the representation of the entering beam.

This work is a collaboration between the IJCLab and the LISN at Paris Saclay with data from the ThomX project, an accelerator currently in commissioning at Orsay.

Auteur principal: GOUTIERRE, Emmanuel ({CNRS}UMR9012)

Co-auteurs: BRUNI, Christelle (CNRS/IJCLab); GULER, Hayg (IJCLAB); Dr COHEN, Johanne; Dr SEBAG, Michèle

Orateur: GOUTIERRE, Emmanuel ({CNRS}UMR9012)

Classification de Session: Monday afternoon

Classification de thématique: 3 ML for simulation and surrogate model : Application of Machine Learning to simulation or other cases where it is deemed to replace an existing complex model

ID de Contribution: **88** Type: **Non spécifié**

Enhanced GNN models for track reconstruction with ATLAS ITk

mardi 27 septembre 2022 14:40 (20 minutes)

Graph Neural Network (GNN)-based algorithms have been shown to produce competitive physics performance for the reconstruction of tracks from charged particles (« tracking ») during the future high-luminosity phase of the LHC (HL-LHC). Initial studies [1,2] of these algorithms were based on the dataset from the TrackML challenge [3], i.e. a simulated dataset created with a number of simplifying assumptions. The most recent studies are based on detailed simulations of the future ATLAS Inner Tracker (ITk) [4,5]. GNN-based algorithms now appear as competitive solutions for the future generation of charged particle track reconstruction algorithms which will have to be put into production for the HL-LHC.

We present in detail the architecture of the Message Passing Neural network (MPNN) model used to obtained these results. We focus on the limitations and on potential shortcomings of the present algorithms in specific regions of the detector. We present new approaches that are being explored to overcome these limitations, like heterogeneous versions of the MPNN model or the use of weights to obtain class ratio and/or graph topology region balance in the loss function. We discuss the interest of evolving the model towards a Graph Transformer-type architecture including attention mechanisms, and of adding topological or detector-geometry-oriented positional encodings to the current encodings of detector hits in euclidian space.

[1] Towards a realistic track reconstruction algorithm based on graph neural networks for the HL-LHC, C.Rougier et al., vCHEP 2021, https://www.epj-conferences.org/articles/epjconf/pdf/2021/05/epjconf_chep2021_03047

[2] Physics and Computing Performance of the Exa.TrkX TrackML Pipeline, D. Murnane et al., vCHEP 2021, https://cds.cern.ch/record/2767568?ln=fr

[3] TrackML challenge: https://www.kaggle.com/c/trackml-particle-identification

[4] Graph Neural Network track reconstruction for ATLAS ITk , D. Murnane et al., IML 2022, https://cds.cern.ch/record/2809518/files/ATL-ITK-SLIDE-2022-119.pdf

[5] ATLAS ITk Track Reconstruction with a GNN-based pipeline, C.Rougier et al., CTD 2022, https://cds.cern.ch/record/2815578

Auteurs principaux: VALLIER, Alexis (L2I Toulouse, CNRS/IN2P3, UT3); ROUGIER, Charline (L2I Toulouse, UT3, CNRS/IN2P3); STARK, Jan (L2I Toulouse, CNRS/IN2P3, UT3); CAILLOU, Sylvain (L2I Toulouse, CNRS/IN2P3)

Orateur: CAILLOU, Sylvain (L2I Toulouse, CNRS/IN2P3)

Classification de Session: Tuesday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **89** Type: **Non spécifié**

A new method for the data driven estimation of background using GAN

mercredi 28 septembre 2022 14:20 (20 minutes)

In this contribution we present a novel data driven method for the estimation of background by generating a new misidentified object using generative adversarial networks (GAN). In High Energy Physics, characterizing signal hypothesis requires distinguishing its signature from a large number of background processes with similar final states. Machine learning (ML) classification algorithms are widely used to obtain the optimal separation between signal and background processes. However, constraints on the storage and computing power restrict the generated sample size, which may cause Monte Carlo (MC) simulation of events with large population weights. The training of ML algorithms with these limited size samples may degrade the classification performance.
Many of these background events come from processes similar to signal process, but with one (or more) misidentified object (such as $\gamma + \mathrm{jets}$ background process for the $\mathrm{H} \rightarrow \gamma\gamma$ analysis). Therefore, a good description of these background processes is important for the sensitivity of the analyses. In this presentation, a novel technique using a GAN based object simulation is presented. A conditional GAN algorithm is used to simulate a new misidentified object for the data events that cannot pass the object identification criteria. Hence, this large sample of filtered out data events can be used in the description of the processes with misidentified objects. We demonstrate that using conditional GAN algorithm, the observables of the generated object retains the correlations with other features.

Auteurs principaux: COUDERC, Fabrice (CEA); MALCLES, Julie (IRFU, CEA-Saclay); SAHIN, Mehmet Ozgur (CEA-Saclay); LOHEZIC, Victor (IRFU (CEA) / Université Paris-Saclay)

Orateur: LOHEZIC, Victor (IRFU (CEA) / Université Paris-Saclay)

Classification de Session: Wed afternoon

ID de Contribution: **91** Type: **Non spécifié**

M4CAST : an emerging national collaborative effort for IA applications to accelerators physics and technologies

lundi 26 septembre 2022 15:50 (20 minutes)

M4CAST, standing for "Multiphysics Modelling, Machine learning and Model-based Control in Accelerator Sciences and Technologies", is a new collaborative effort gravitating around artificial intelligence applications for accelerator physics and technologies. It intends to bridge accelerators under operation and future projects. It also tries to bring closer various scientific communities. Among them, some mainly concentrate on reliability of existing facilities, others develop the next generation accelerators ; some play with data, others design and build cutting edge beam delivering facilities. Data sharing and common methods take an important part in these developments. This effort is also integrated within a national roadmap and European emerging efforts for IA applications to particles accelerators. This presentation shows the current status of the M4CAST collaboration and the ongoing and planned developments within its frame.

Auteur principal: GHRIBI, Adnan ({CNRS}UPR3266)

Co-auteurs: DALENA, Barbara (IRFU); POIRIER, Freddy (CNRS/Arronax); BOULY, Frédéric (CNRS/IN2P3/LPSC); GULER, Hayg (IJCLAB)

Orateur: GHRIBI, Adnan ({CNRS}UPR3266)

Classification de Session: Monday afternoon

Classification de thématique: 8 ML for particle accelerators (only if does not fit in Tracks above)

ID de Contribution: **92** Type: **Non spécifié**

Classification of astrophysical image time series using convolutional attention

lundi 26 septembre 2022 14:20 (20 minutes)

We will present the collaborative work between astrophysicists and computer scientists to explore classification of optical transients. The optical transient time serie, captured with its scene (usualy a galaxy in the background) is used as raw input into a convolutional attention network to performe supervised learning on several class of astrophysical transient objects. Results and comparison with other state-of-the-art methods are presented.

Auteur principal: M. BAIROUK, Anass (LIRMM, Montpellier)

Co-auteurs: FOUCHEZ, Dominique (CPPM); Prof. COMBY, Frederic (LIRMM, Montpellier); Prof. PASQUET, Jerome (Tetis, Montpellier); BAUTISTA, Julian (Aix-Marseille Univ, CPPM); Prof. CHAUMONT, Marc (LIRMM, Montpellier)

Orateurs: BAIROUK, Anass; FOUCHEZ, Dominique (CPPM)

Classification de Session: Monday afternoon

Classification de thématique: 1 ML for object identification and reconstruction

ID de Contribution: **93** Type: **Non spécifié**

Introduction

lundi 26 septembre 2022 11:00 (20 minutes)

Orateurs: BOUCAUD, Alexandre (APC / IN2P3); ROUSSEAU, David (IJCLab, CNRS/IN2P3, Université Paris-Saclay); GAUTARD, Valérie (CEA-Irfu)

Classification de Session: Monday morning

ID de Contribution: **94** Type: **Non spécifié**

Round table

lundi 26 septembre 2022 11:20 (20 minutes)

Classification de Session: Monday morning

ID de Contribution: **95** Type: **Non spécifié**

Boosting event generation and inference with new machine learning methods

lundi 26 septembre 2022 11:40 (50 minutes)

First-principle simulations are at the heart of the high-energy physics research program. They link the vast data output of multi-purpose detectors with fundamental theory predictions and interpretation. In this talk I will discuss a range of applications of modern machine learning to event generation and simulation-based inference, including conceptional developments driven by the specific requirements of particle physics.

Orateur: BUTTER, Anja (ITP U Heidelberg/LPNHE)

Classification de Session: Monday morning

ID de Contribution: **96** Type: **Non spécifié**

AISSAI semestre IN2P3

mardi 27 septembre 2022 14:00 (20 minutes)

https://www.cnrs.fr/fr/le-centre-artificial-intelligence-science-science-artificial-intelligence-aissai

Orateur: FADILI, Jalal (CNRS/INS2I)

Classification de Session: Tuesday afternoon

ID de Contribution: **97** Type: **Non spécifié**

CC TBC

Classification de Session: Monday afternoon

ID de Contribution: **98** Type: **Non spécifié**

European Open Science Cloud : open science, open data

mardi 27 septembre 2022 17:10 (30 minutes)

L'European Open Science Cloud (EOSC) vise à fournir aux chercheurs européens un accès transparent aux données, services et e-infrastructures FAIR. L'objectif est d'améliorer la productivité de la recherche en général. En tant que tel, l'EOSC est également un pilier de la transition numérique en France, qui comprend des efforts pour mutualiser les services et les e-infrastructures au profit de l'ensemble de la communauté de recherche.
Pour libérer tout le pouvoir et l'impact des données de recherche, il est nécessaire de les rendre FAIR, et surtout de les rendre lisibles par machine. Cela permet d'utiliser ces données à l'aide de techniques avancées, comme le ML et l'IA.
Ainsi, permettre aux services ML d'explorer les données FAIR est l'un des objectifs clés de l'EOSC.
Je présenterai brièvement l'EOSC et montrerai comment la Commission européenne soutient le développement de services ML.

Orateur: BECKMANN, Volker (MESR / DGRI / SSRI / A7)

Classification de Session: Tuesday afternoon

ID de Contribution: **100** Type: **Non spécifié**

Scope of IN2P3 ML project

mardi 27 septembre 2022 11:40 (50 minutes)

Orateurs: BOUCAUD, Alexandre (APC / IN2P3); ROUSSEAU, David (IJCLab, CNRS/IN2P3, Université Paris-Saclay)

Classification de Session: Tuesday morning

ID de Contribution: **101** Type: **Non spécifié**

AISSAI IN2P3 Machine Learning semester brain storm

mercredi 28 septembre 2022 15:00 (30 minutes)

Classification de Session: Wed afternoon

ID de Contribution: **102** Type: **Non spécifié**

Wrap-up and Farewell

mercredi 28 septembre 2022 15:30 (10 minutes)

Orateurs: BOUCAUD, Alexandre (APC / IN2P3); ROUSSEAU, David (IJCLab, CNRS/IN2P3, Université Paris-Saclay); GAUTARD, Valérie (CEA-Irfu)

Classification de Session: Wed afternoon

ID de Contribution: **103** Type: **Non spécifié**

Round table on emerging topic

mercredi 28 septembre 2022 11:35 (50 minutes)

Classification de Session: Wed morning

ID de Contribution: **104** Type: **Non spécifié**

Neural Posterior Estimation with Differentiable Simulators

mercredi 28 septembre 2022 10:50 (20 minutes)

Simulation-Based Inference (SBI) is a promising Bayesian inference framework that alleviates the need for analytic likelihoods to estimate posterior distributions. Recent advances using neural density estimators in SBI algorithms have demonstrated the ability to achieve high-fidelity posteriors, at the expense of a large number of simulations ; which makes their application potentially very time-consuming when using complex physical simulations. In this work we focus on boosting the sample-efficiency of posterior density estimation using the gradients of the simulator. We present a new method to perform Neural Posterior Estimation (NPE) with a differentiable simulator. We demonstrate how gradient information helps constrain the shape of the posterior and improves sample-efficiency.

Auteurs principaux: BOUCAUD, Alexandre (APC / IN2P3); LANUSSE, Francois ({CNRS}UMR7158); ZEGHAL, Justine (APC)

Co-auteurs: REMY, Benjamin (CEA Paris-Saclay); AUBOURG, Eric (APC)

Orateur: ZEGHAL, Justine (APC)

Classification de Session: Wed morning

Classification de thématique: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detectio

ID de Contribution: **105** Type: **Non spécifié**

Dealing with uncertainties in Machine Learning

mardi 27 septembre 2022 10:50 (50 minutes)

Over the past decade, Deep Learning became an essential approach in many fields, from classical image processing to several scientific and very specific domains. It often shows very promising performances, outperforming human performances in some specific tasks, and even classical methods for some applications. However, because of a lack of theory that can guarantee their performances, the question of the reliability of these models has been raised. More specifically, it would be a desired property of these models if they were able to provide a confidence level associated to their predictions. A possible formalism to address this question comes from the study of uncertainty quantification in deep learning. In this talk, we first try to give some definitions of uncertainties and the associated metrics, in the cases of classification and regression problems. Then, we describe some state-of-the-art methods that have been developed to estimate uncertainties for Deep Learning models and understand their limitations. Finally, we present a methodology to validate the estimated uncertainties by empirical tests.

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Classification de Session: Tuesday morning

Classification de thématique: 6 ML training, courses, tutorial, open datasets and challenges

ID de Contribution: **106** Type: **Non spécifié**

Hackathon to fill in IN2P3 ML web site

lundi 26 septembre 2022 16:50 (1 heure)

If you want your favourite publication, tutorial, or project to be on https://machine-learning.pages.in2p3.fr/ just stay around

Classification de Session: Monday afternoon

ID de Contribution: **107** Type: **Non spécifié**

A reminder of some events : JI 2022 & DL Training

mercredi 28 septembre 2022 11:30 (5 minutes)

Orateur: BOUVET, Françoise (IJCLab)

Classification de Session: Wed morning