Iniziative cross-domain

Simone Gennai, INFN Bicocca



Iniziative cross-domain (con "appeal" per l'industria)

□ XAI: eXplainable AI

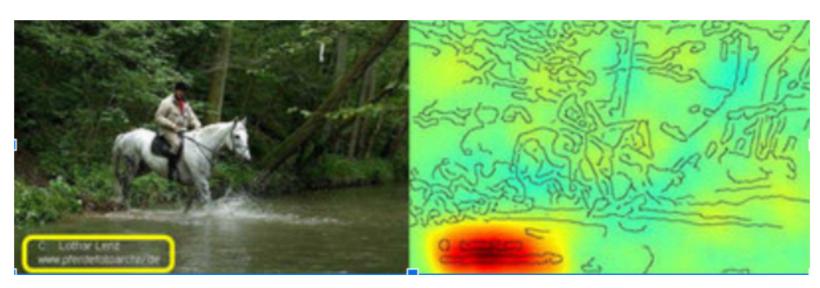
- □ Un ramo di Al che utilizza modelli "facilmente" spiegabili all'essere umano per poter interpretare il motivo di una data risposta, e:.g.
 - □ Perchè un dato evento e' stato classificato come segnale invece che fondo ...
 - □ ... ma anche perche' l'algoritmo ML della mia banca mi ha rifiutato il mutuo ...
 - □ ... o ancora perchè l'algoritmo ha diagnosticato una data malattia ... etc. etc.
 - Sta diventando sempre piu' importante soprattutto al di fuori della fisica delle particelle proprio a casua delle ripercussioni legali che si possono avere quando si basano determinate scelte su algoritmi complessi

DQM: Data Quality Monitoring

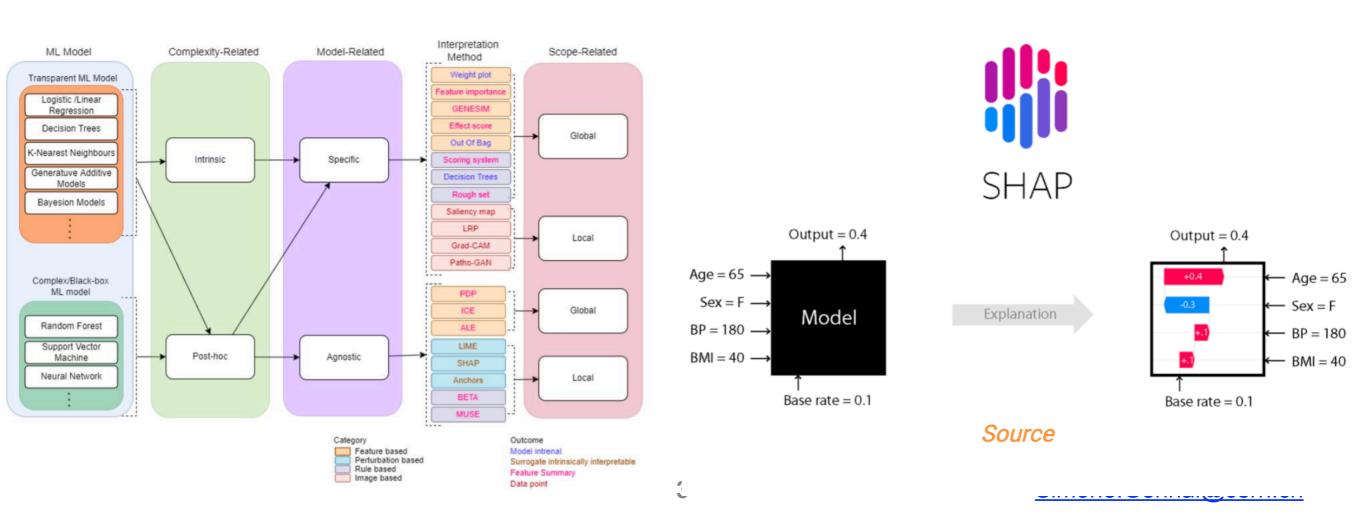
- Nel caso di HEP si tratta del processo che permette di certificare i dati raccolti come "buoni" per l'analisi successiva
- Può essere di interesse per aziende che si preoccupano di monitorare (o offrire tool per monitorare) il corretto funzionamento dei loro prodotti



eXplainable Al



Source: https://www.nature.com/articles/s41467-019-08987-4



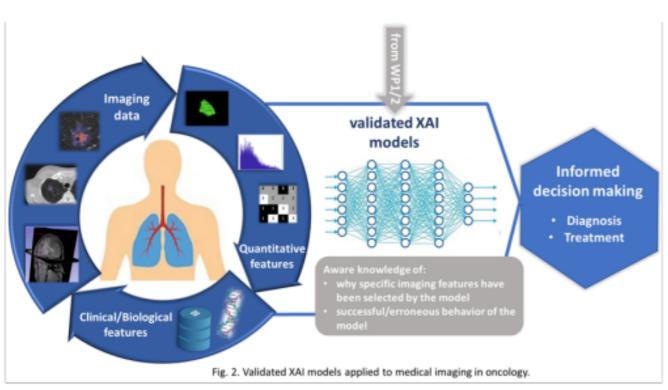


Attivitá legate a XAI in Italia

- EXPANSION: EXPlainable AI through high eNergy physicS for medical Imaging in ONcology
 - □ Proposta di PRIN tra Politecnico di Milano, INFN Bicocca e Università/INFN di Perugia
 - Uso di canali di HEP per tuning di algoritmi di XAI da applicare per identificazione di tumori
 - Un PhD sta partendo al Politecnico con una borsa a tema pagata sui fondi PNRR
- MUCCA project (finanziato con un Chist-era grant: CHIST-ERA-19-XAI-009)
 - □ Filosofia simile al progetto PRIN, l'idea e' di migliorare i tool per XAI tramite analisi dati in diversi domini
 - □ PI: Stefano Giagu
- □ Varie attività legate a fisica medica, e.g. gruppo fisica medica università di Bari
 - https://agenda.infn.it/event/29907/contributions/163456/attachments/90346/121687/ AI%40INFN_LombardiAngela.pdf
- □ <u>https://xai-project.eu</u> (ERC da 2.5M Euro)
 - □ PI: Fosca Giannotti, Scuola Normale Superiore Pisa
 - ☐ Uso di XAI con finalità nel sociale e imprese



EXPANSION



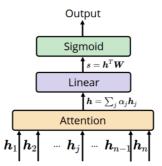


Figure 1: Classification architecture with attention

Start with a sequence: e_1,\dots,e_m after the LSTM you'll have, $h_{i,j} \in \mathbb{R}^{n \times m}$ which is the encoded representation. A context vector is defined as

$$^{C}i=\,\alpha_{i,j}\times\,h_{j}$$

Where alpha is the attention weight computed as:

$$\alpha_{ij} = \frac{\exp\left(e_{ij}\right)}{\sum_{k=1}^{T_x} \exp\left(e_{ik}\right)},$$

eij being parametrized as a feedforward output on the representation.

The weighted context vector is then processed through the sigmoid output

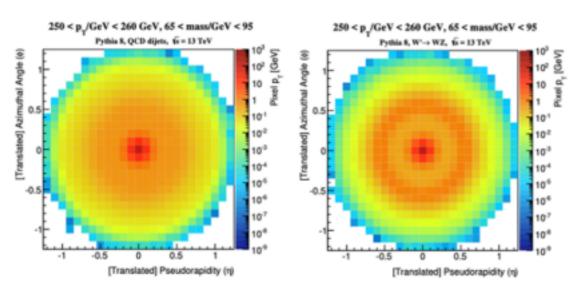


Fig. 3. Average jet images as resulting from treating each particle constituent as a pixel with the color matching the energy scale of the particle. The left plot refers to QCD jets while the right one refers to boosted massive objects, where a different expected pattern distribution of jet constituents are clearly visible [49].

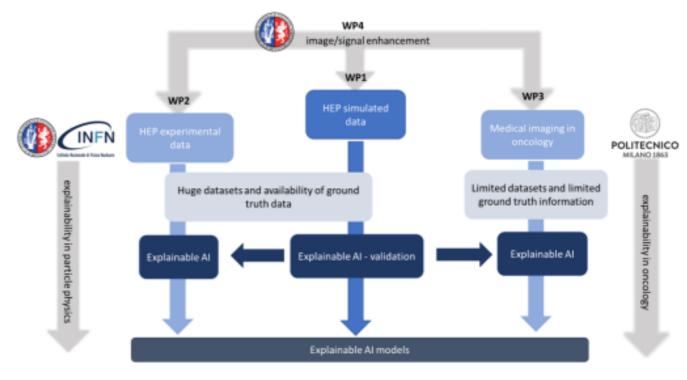
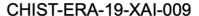
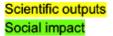


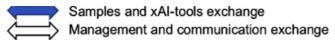
Fig. 1. Structure of the project with research units involved.

MUCCA



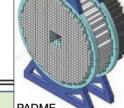






Tools for detectors

xAl tools,



PADME

Publication, Real-time application tools Open doors days_

WP1: HEP physics

Application of Al-methods to searches for new physics at ATLAS. Provide samples and tools to allow testing of xAI. Improve transparency, impact of systematics explainability. Deliverables: HEP publications, benchmarks use-cases, generalized tools.

> School/Hackaton publications

WP0: Management

Project and reports coordination. planning of meetings, networking and participation in public conferences. Kaggle challenge Dissemination, communication and exploitation of results (publications, reports, social media)

> Brain-Computer Interfaces Meetings stakeholders

Open doors days Diagnostic tools

WP2: HEP detectors

Application of Al-methods to calorimeter detectors (PADME). Provide simulation of electromagnetic showers, benchmarking and tools for xAI. Deliverables: samples and tools for xAI methods, reports.

WP7: xAI-Tools

Survey of all available xAl methods relevant for use-cases; develop xAI usage pipelines; analysis of results.

Deliverables: document xAI procedures and engineering pipelines for general use. Kaggle challenge for exploitation.

WP6: Neuro-science

computational brain strategies on NHP

and selection of dynamical neural models

Deliverables: reports on saliency maps

from DNNs trials, quantification of quality

Test xAI techniques to uncover

and model selection.

Develop xAI pipeline to segmentation of brains in magnetic resonance imaging. Use publicly available databases for xAI developments, focusing on explainability of training strategy. Deliverables: xAl algorithms and stability evaluation.

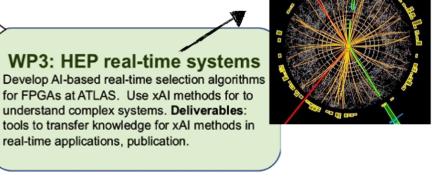
WP4: Medical imaging

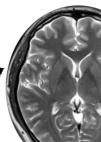
understand complex systems. Deliverables:

real-time applications, publication.

WP5: Functional Imaging

Test xAI methodology in respiratory system. Analyse complex systems (passage of air and mucus, expected nonlinear responses) to derive model and test xAI. Deliverables: prototype of xAI algorithm implementation, assessment of produced predictions.

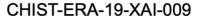




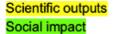


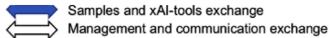


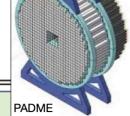
MUCCA











Publication, Real-time application tools

Open doors days

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Application of Al-methods to searches for

and tools to allow testing of xAI. Improve

School/Hackaton

Brain-

Computer Interfaces

new physics at ATLAS. Provide samples

transparency, impact of systematics explainability. **Deliverables:** HEP publications, benchmarks use-cases,

Tools for detectors

xAl tools,

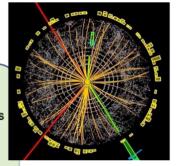
Kaggle challenge

WP2: HEP detectors

Application of Al-methods to calorimeter detectors (PADME). Provide simulation of electromagnetic showers, benchmarking and tools for xAl. **Deliverables:** samples and tools for xAl methods, reports.



Develop AI-based real-time selection algorithms for FPGAs at ATLAS. Use xAI methods for to understand complex systems. **Deliverables**: tools to transfer knowledge for xAI methods in real-time applications, publication.



generalized tools.

WP0: Management

planning of meetings, networking and

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participation in public conferences.

Dissemination, communication and exploitation of results (publications,

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∭ publications

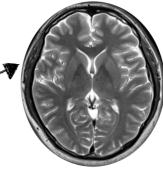
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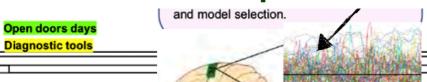
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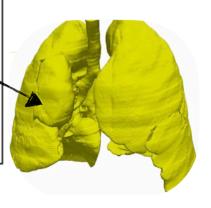
Test xAI techniques to uncover

Computational demanding



algorithm implementation, assessment of produced predictions.

WP5: Functional Imaging





XAI-Project

SCIENCE AND TECHNOLOGY FOR THE EXPLANATION OF AI DECISION MAKING.

The XAI project, focuses on the urgent open challenge of how to construct meaningful explanations of opaque AI/ML systems in the context of ai based decision making, aiming at empowering individual against undesired effects of automated decision making, implementing the "right of explanation", helping people make better decisions preserving (and expand) human autonomy.

News: Collaborazione tra SNS
e intesa San Paolo su
Un algoritmo in grado di
spiegare il motivo dei
suggerimenti commerciali
bancari

RESEARCH LINES 1. LOCAL TO GLOBAL

2.
CASUAL
EXPLANATION

3.
PLATFORM
XUI

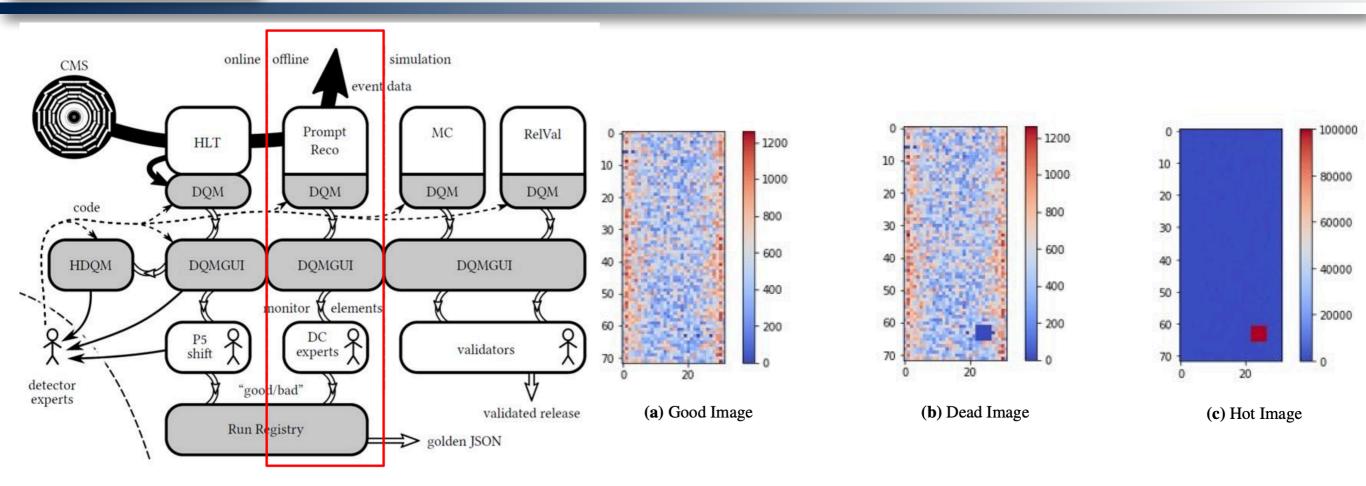
4.
CASE
STUDIES

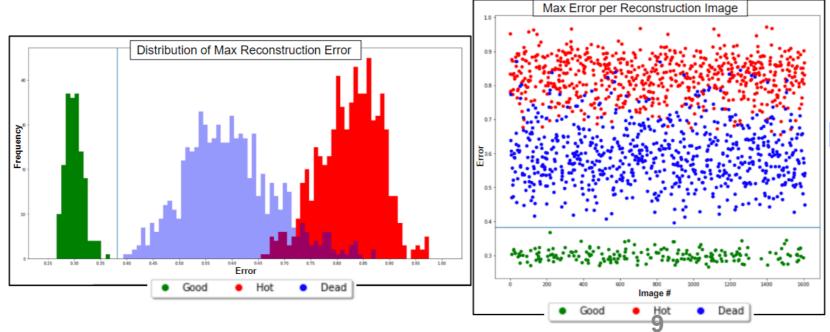
5. ETHICS LEGAL

- □ Pubblication list: https://xai-project.eu/resources.html#publications
- □ More news at : https://xai-project.eu/news.html



Data Quality Monitoring





L'interesse al momento e' su certificazioni delle singole LS Dove condizioni possono variare durante il Fill di presa dati



Attività in Italia & friends

□ Università e INFN Firenze

- Attività pregressa con Francesco Fiori (che però ha lasciato l'accademia)
- □ Interesse a trasferire concetti relativi al domain adaptation alla LS based certification
 - https://arxiv.org/pdf/2207.09293.pdf
- □ Baker Hughes Inc. (Valentina Gori)
 - □ Collaborazione con università di Firenze sempre sull'argomento domain adapatation
 - https://arxiv.org/abs/2201.03850
 - □ https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9870234
- Long standing project with CERN openlab:
 - https://twiki.cern.ch/twiki/bin/viewauth/CMS/ML4DQM
 - □ Non e' chiaro se il progetto e' ancora in atto, ultimi dettagli sono relativi al 2020 ...



Computing needs

- CERN openlab "aveva" una collaborazione con IBM per il ML4DQM-DC
 - □ IBM metteva a disposizione SW e HW per il training (Minsky cluster)
 - □ In atto dal 2018 (circa) non e' chiaro se sia ancora attiva

IBM S821LC (8001-12C)

- . 8 P8 cores @ 2.32 GHz
- . 64 GB DDR4
- . 8 TB HDD
- . 1 GbE (/ 10 GbE)

Hardware

1BM S822LC for HPC (8335-GTB)

- . 16 P8 cores @ 3.26/3.86 GHz
- . 256 GB DDR4
- . 4x NVIDIA P100 3584 CUDA cores, 16 GB HBM2
- . 4 TB HDD + 1.6 TB NVMe
- . IB EDR
- . 1 GbE
- . Xilinx ADM-PCIE-8K5 (CAPI)

CentOS 7.4 ppc64le

CernVM-FS

NVIDIA CUDA 9.1

IBM PowerAl 1.5

slurm

IBM Spectrum Conductor for

Spark & Deep Learning

: Impact (in progress)

Software



Testbeds

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The second	- / \ / \ \ I

- □ Lato HEP clusters di GPU di media grandezza (~8) dovrebbero essere sufficienti
- ☐ Per quanto riguarda il progetto MUCCA:
 - □ come testbed hanno usato HPC in Sapienza da 400M Euro con ~16 GPU (2PFlop)
 - Alcuni WP (non ancora finalizzati) usano modelli computazionali complessi su fluidodinamica per respirazione e neuroscienze con sensori da cervelli di scimmie, quelli necessitano maggiori potenze computazionali
 - □ In Sapienza stanno comprando un'altra macchina della Invidia, ma potrebbe arrivare tardi per il progetto,
 - potrebbero servire risorse di calcolo da altri parti
 - □ Per la parte di FPGA:
 - Per i modelli a bassisima latenza hanno usato le FPGA di ATLAS
 - Per i modelli a latenza piu' alta, hanno comparato una FPGA di tipo PCIe con i fondi del progetto, ma adesso servirebbero board piú evolute.
 - □ Possibile punto di contatto con il progetto di Punzi (vedi agenda WP4)

□ DQM

- Quantità di plot da analizzare varia a seconda di quali sub-detector si vogliono monitorare
- ☐ CMS mette a disposizione 110k plot con dati del 2017 con la granularità della LS (23 secondi)
 - Ci sono tool per estrarre i dati dai plot e usarli in formato Pandas DF per il training
 - □ Maggiori informazioni su : https://twiki.cern.ch/twiki/bin/viewauth/CMS/ML4DQM (non aggiornata dal 2020 ...)
- □ Necessità di generated labelled samples per quantificare le performance degli algoritmi
 - □ Bad data is too small ...



Back up



The attention mechanism

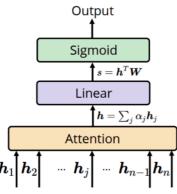


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Use of the attention weights to inspect the DNN decision

- We can scan the events that has been properly classified (or not)
- and check those jets that mostly drove the decision
 - Signal events have max 1 jet with high attention weight
 - QCD shows larger multiplicity of jets with nearby values of attention weights

Giacomo Boldrini

