The ML_INFN initiative

L. Anderlini, on behalf of the ML_INFN initiative
The ML_INFN initiative

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Machine Learning Technologies for INFN

Most of the experiments and initiatives produce, analyse or process digital data.

Enthusiasm on the modern data processing technologies!

Gravitational wave detection

Raw radiation detector data

Research on innovative imaging technologies
The potential barriers

Employing machine learning techniques often requires:

- specialized hardware and software setup
- specific training to identify tools and learning resources
- a community of experts providing support to research use cases
Employing machine learning techniques often requires:

- **specialized hardware and software setup**
  
  **WP1**: provide a centrally maintained cloud-based infrastructure for interactive and batch ML fast prototyping, with access to modern GPU hardware and systems tuned for ML performance.

- **specific training to identify tools and learning resources**
  
  **WP2**: organize national training events for INFN users (Machine Learning hackathons).

- **a community of experts providing support to research use cases**
  
  **WP3**: provide and organize example applications in a knowledge base.
The numbers of ML_INFN

11 INFN structures involved in the preparation of the knowledge base

79 researchers devoting a fraction of their time to promote ML techniques for research

16 professional GPUs made available and accessible through the INFN Cloud Interface

110 participants to the hackathons, ranging from students to permanent staff members
WP1. The infrastructure
**INFN Cloud**

**ML_INFN** is built on top of **INFN Cloud**: a data lake-centric, heterogeneous federated Cloud infrastructure spanning multiple sites across Italy, providing an extensible portfolio of solutions tailored to multidisciplinary scientific communities.
Federated baremetal resources

1x SuperMicro + 1x E4 servers:

- 1 TB RAM
- 64-128 CPU cores
- 36 TB local storage (NVMe)
- 8x Tesla T4 GPUs
- 5x RTX 5000 GPUs
- 1x A30 GPU
- 2x A100 GPUs
- 10 GbE connection to CNAF resources

Federated to CNAF OpenStack and INFN Cloud

Storage solutions
Storage from CERN experiments can be mounted with NFS from the Tier-1 storage
Hypervisors integrated to Ceph to manage persistent virtual volumes accessed from the VM with POSIX
WP2. Stewardship
Hackathons in Covid-19 Era

Originally planned as satellite events of scientific workshops, canceled due to pandemic, hackathons have been transformed in virtual events.

Registrations limited to 60 to guarantee decent tutor-per-student and RAM-per-student ratios.
# Lecture Program

## Day 1
- **Lectures**
  - Theoretical introduction to ML
- **Lectures**
  - Cloud and Cloud Resources

## Day 2
- **Hands-on**
  - Neural Networks
- **Seminars**
  - Deep Neural Network Applications to INFN research

### Lunch break

## Day 3
- **Hands-on**
  - Exercises with tutors *continuous support*
- **Hackathon**
  - Exercises with tutors *on demand*
- **Closure**
  - Reports from the students

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**Lecture Program**

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| Theoretical introduction to ML | Neural Networks         | Exercises with tutors *continuous support*
| Cloud and Cloud Resources | Deep Neural Network Applications to INFN research | |
| **Hands-on**            | **Seminars**           | **Closure**            |
| Numpy, Pandas and Keras | Exercises with tutors *on demand* | Reports from the students |
| **Closure**             |                        |                        |
Hackathon use cases: 10 groups, one tutor per group

Jet b-tagging at CMS
Recurrent Neural Networks with LSTM

Higgs searches at CMS
Deep Neural Networks and Advanced Keras

Gravitational Waves with Virgo
Autoencoders, anomaly detection and compression

Segmentation of CT scans
Convolutional Neural Networks Handling 2D and 3D datasets
Final survey

A satisfaction questionnaire was submitted to the participant at the end of each event.

Generous feedback on:

- Level of difficulty
- Relevance and interest
- Technical setup

About a half of the participant responded they would have been willing to spend more time on the hands on and/or the hackathon.
Advanced Hackathon in Bari
21 – 24 November 2022

Registrations for the upcoming Advanced Hackathon are open. Register now.

Planned exercise topics:

- Image segmentation in Medical Physics
- Domain Adaptation in HEP
- Graph Neural Networks and Transformers
- Explainable AI

The event will be in person and a maximum of 20 participants will be accepted.

Objectives of the initiative:

- Present and discuss realistic applications of advanced algorithms to INFN research, looking into the code;
- Advertise INFN Cloud for sharing computing resources;
- Enhance networking of advanced ML practitioners within INFN.
WP3. Network and Knowledge Base
Atlassian Confluence was used to build a **Knowledge Base** reporting several machine-learning use cases, including those discussed at the hackathon.

Each entry includes:

- **Runnable example** as a jupyter notebook or a git repository
- **Contact information** of one or more experts
Publications


L. Banchi et al. “Generalization in Quantum Machine Learning: A Quantum Information Standpoint”, PRX Quantum 2, 040321


G. Graziani et al., “A Neural-Network-defined Gaussian Mixture Model for particle identification applied to the LHCb fixed-target programme”, JINST 17 (2022) P02018

... and counting
Summary and conclusions
Summary

The ML_INFN initiative has been providing many INFN experiments with the hardware and the knowledge base to assess the potential benefit of machine learning to their research for three years.

The ML_INFN project relies on INFN Cloud solutions and it federates resources optimized for ML performance in interactive and batch-like usage patterns (high-end professional GPUs, NVMe disks, many-core high-RAM systems).

A series of national training events (machine learning hackathons) and a collection of tutorials and real applications within the INFN community (knowledge base) contribute to building a network of experienced and enthusiast machine learning practitioners, lowering the skill gap to benefit from machine learning developments.
Outlook

Machine Learning is here to stay. In the next future:

● We will organize **Advanced Training Course(s)** on Deep Learning

● We will provide Cloud-based access to **FPGAs** as **Machine Learning accelerators**
  ○ Two U50 and a U250 Xilinx FPGAs recently federated to the cloud
  ○ Already accessed through virtual machines, aiming at provisioning FPGAs as a Service

● We will keep supporting students and researchers employing **Machine Learning technologies** in their daily activities.