



Final preparations ahead of the 1st AI_INFN Advanced Hackathon

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CNAF

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The hackathon is fast approaching


1st AI-INFN Advanced Hackathon

26–28 Nov 2024
University of Padua, Complesso Paolotti
Europe/Rome @infn

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Overview
Timetable [Preliminary]
Registration
Experts and tutors

Contact
✉ ml-infn-hackathons@list...



Welcome to the First edition of the Advanced Artificial Intelligence @ INFN (AI_INFN) hackathon, dedicated to INFN affiliates. This edition is hosted at INFN Sezione di Padova.

Notably, it is the third Hackathon to happen in Person, so please apply only if you are planning to come to Padua. The logistics allow for ~ 20 participants.

26–28 Nov 2024

University of Padua, Complesso Paolotti



<https://agenda.infn.it/event/43129>

First two-days programme

Tue 26/11

09:00	Welcome Classrooms P2B and P4C, University of Padua, Complesso Paolotti	09:00 - 09:20
	AI in Europe and WLCG vision Tommaso Boccali	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	09:20 - 10:00
10:00	Cloud Veneto and INFN Cloud Marco Verlati	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	10:00 - 10:40
	Hands-on: accessing the Hackathon resources Classrooms P2B and P4C, University of Padua, Complesso Paolotti	10:40 - 11:00
11:00	Coffee break Classrooms P2B and P4C, University of Padua, Complesso Paolotti	11:00 - 11:20
	Processing data from the LHCI detector Mr. Andrea Paccagnella et al.	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	11:20 - 12:00
12:00	Generative models to unfold detector effects Fabio Rossi et al.	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	12:00 - 13:00

14:00		
15:00	Use of a multidimensional CNN for particle identification in the LHCI experiment Mr. Andrea Paccagnella et al.	Generative Adversarial Networks as a tool to unfold detector effects Tommaso Vittoni et al.
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	Classrooms P2B and P4C, University of Padua, Complesso Paolotti
	14:30 - 16:00	14:30 - 16:00
16:00	Coffee break Classrooms P2B and P4C, University of Padua, Complesso Paolotti	16:00 - 16:20
	Generative Adversarial Networks as a tool to unfold detector effects Tommaso Vittoni et al.	Use of a multidimensional CNN for particle identification in the LHCI experiment Mr. Andrea Paccagnella et al.
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	Classrooms P2B and P4C, University of Padua, Complesso Paolotti
	16:20 - 18:00	16:20 - 18:00
18:00		

Wed 27/11

09:00	Introduction to Quantum Machine Learning Laura Cappelli et al.	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	09:00 - 10:35
	Quantum-inspired tensor-network machine learning: finding optimal hyperparameters, libraries, and hardware Daniel Jaschke	
10:00	Coffee Classrooms P2B and P4C, University of Padua, Complesso Paolotti	11:00 - 11:20
	Magnetic Resonance Imaging Seminar Francesca Izzo	
11:00	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	11:20 - 12:20
12:00	Introduction to Medical Physics exercise Francesca Izzo	
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	12:20 - 13:00
13:00		

14:00		
15:00	Autism Spectrum Disorders (ASD) diagnosis using structural and functional Magnetic Resonance Imaging and Radiomics Francesca Izzo et al.	Quantum Machine Learning applications: classification, anomaly detection and QUBO problems Laura Cappelli et al.
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	Classrooms P2B and P4C, University of Padua, Complesso Paolotti
	14:30 - 16:00	14:30 - 16:00
16:00	Coffee break Classrooms P2B and P4C, University of Padua, Complesso Paolotti	16:00 - 16:20
	Quantum Machine Learning applications: classification, anomaly detection and QUBO problems Laura Cappelli et al.	Autism Spectrum Disorders (ASD) diagnosis using structural and functional Magnetic Resonance Imaging and Radiomics Francesca Izzo et al.
	Classrooms P2B and P4C, University of Padua, Complesso Paolotti	Classrooms P2B and P4C, University of Padua, Complesso Paolotti
	16:20 - 18:00	16:20 - 18:00
17:00		
18:00		

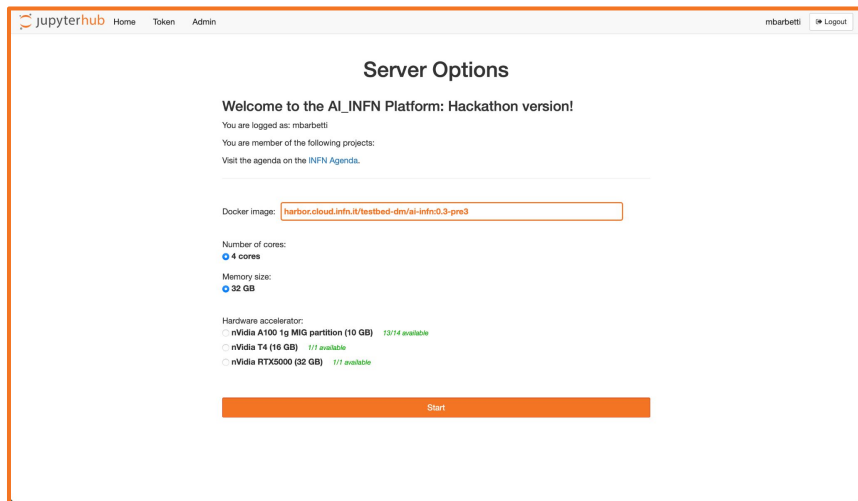
4 exercises:

- **Multidimensional CNN-based model for LHCf**
 - short name: **lhcf-cnn**
- **GAN to unfold detector effects**
 - short name: **gan-detector**
- **AI-powered model for ASD diagnosis**
 - short name: **asd-diagnosis**
- **Quantum Machine Learning applications**
 - short name: **quantum-ml**

<https://agenda.infn.it/event/43129/timetable>

Two AI_INFN-like platforms for the hackathon

Cloud@CNAF



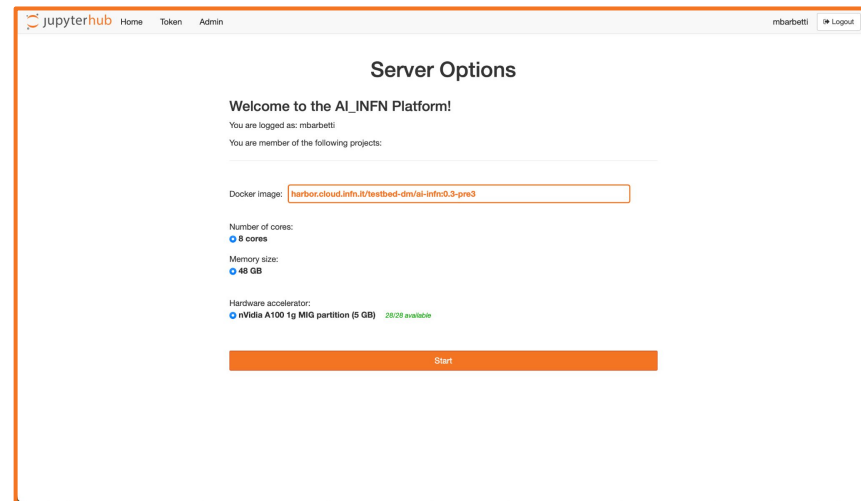
The screenshot shows the 'Server Options' page for the AI_INFN Platform (Hackathon version) on the Cloud@CNAF platform. The user is logged in as 'mbarbetti'. The page displays the following configuration options:

- Docker image: `harbor.cloud.infn.it/testbed-dm/ai-infn-0.3-pre3`
- Number of cores: 4 cores
- Memory size: 32 GB
- Hardware accelerator:
 - nVidia A100 1g MIG partition (10 GB) 13/14 available
 - nVidia T4 (16 GB) 1/1 available
 - nVidia RTX5000 (32 GB) 1/1 available

A 'Start' button is visible at the bottom of the configuration area.

<https://hackathon.ai.cloud.infn.it>

Cloud@ReCaS



The screenshot shows the 'Server Options' page for the AI_INFN Platform on the Cloud@ReCaS platform. The user is logged in as 'mbarbetti'. The page displays the following configuration options:

- Docker image: `harbor.cloud.infn.it/testbed-dm/ai-infn-0.3-pre3`
- Number of cores: 8 cores
- Memory size: 48 GB
- Hardware accelerator:
 - nVidia A100 1g MIG partition (5 GB) 28/28 available

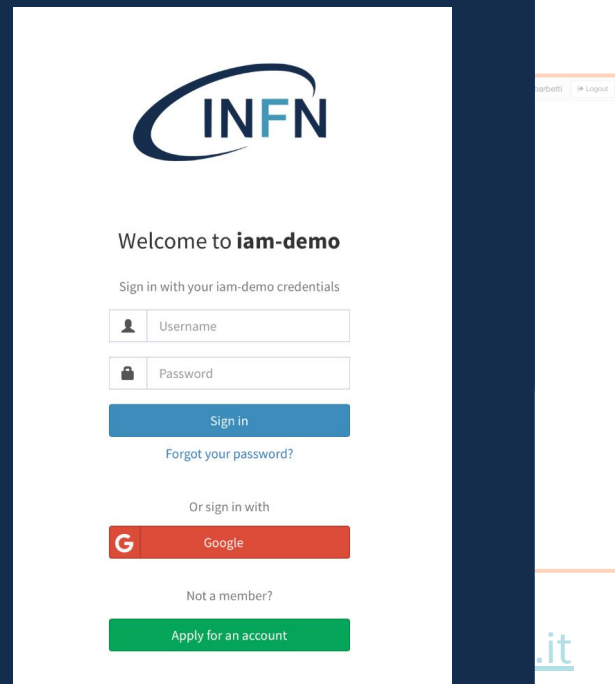
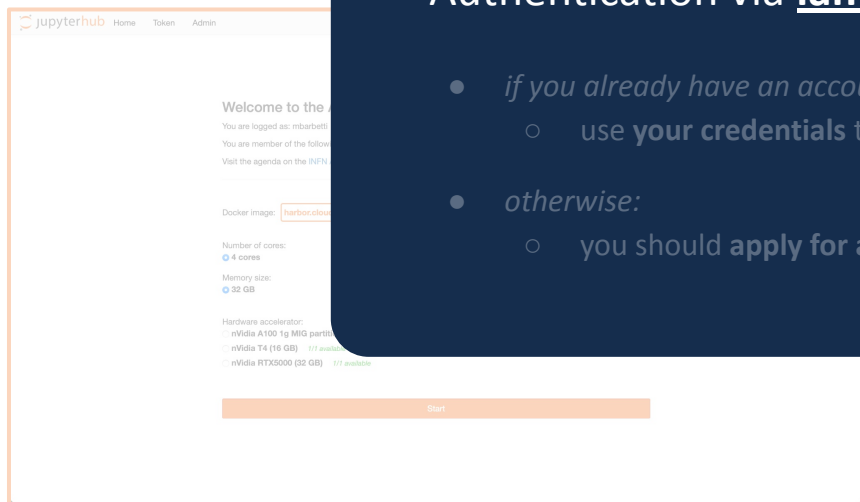
A 'Start' button is visible at the bottom of the configuration area.

<https://hpc-gpu-8-2-10.recas.ba.infn.it>

Two AI_INFN-like platforms for the hackathon

Authentication via iam-demo

- *if you already have an account:*
 - use **your credentials** to access
- *otherwise:*
 - you should **apply for a new account**



<https://hackathon.ai.cloud.infn.it>



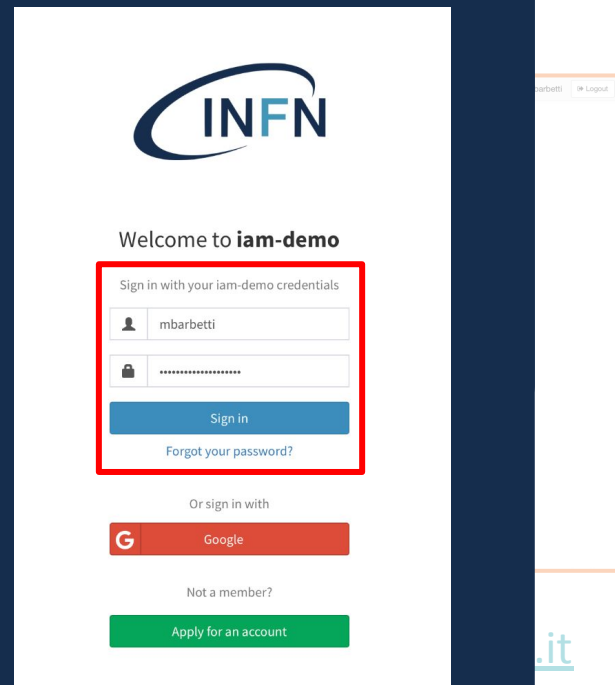
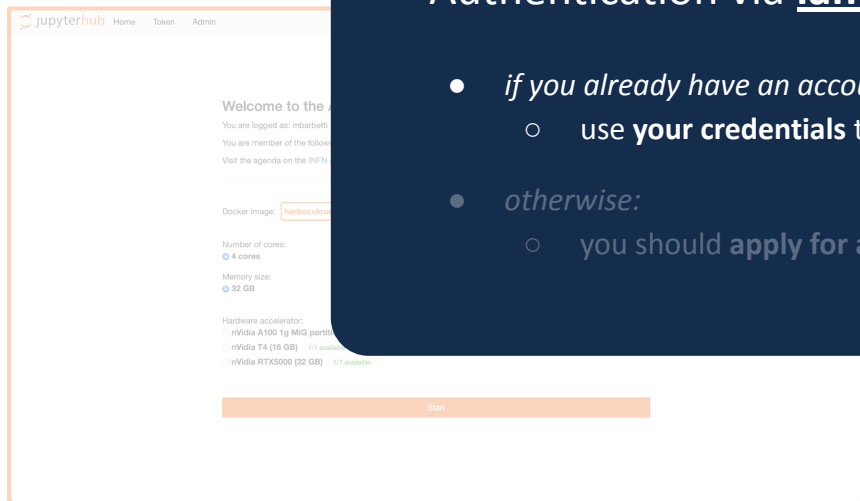
<https://hackathon.ai.cloud.infn.it>

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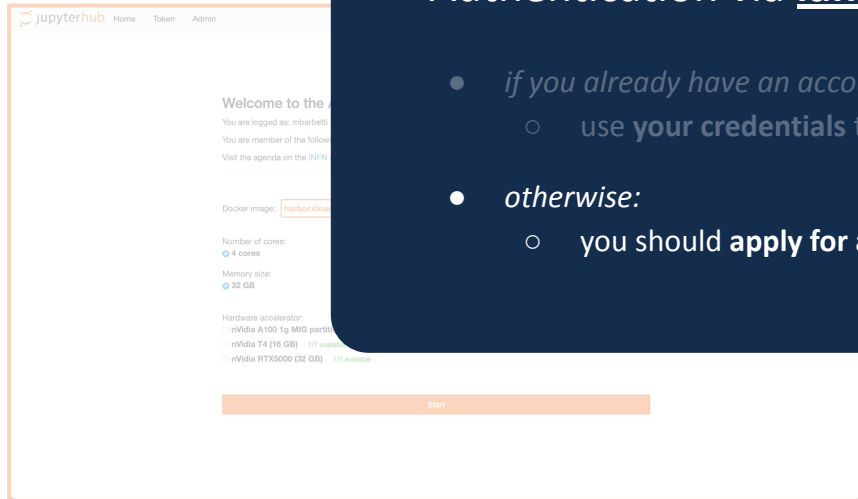


<https://hackathon.ai.cloud.infn.it>

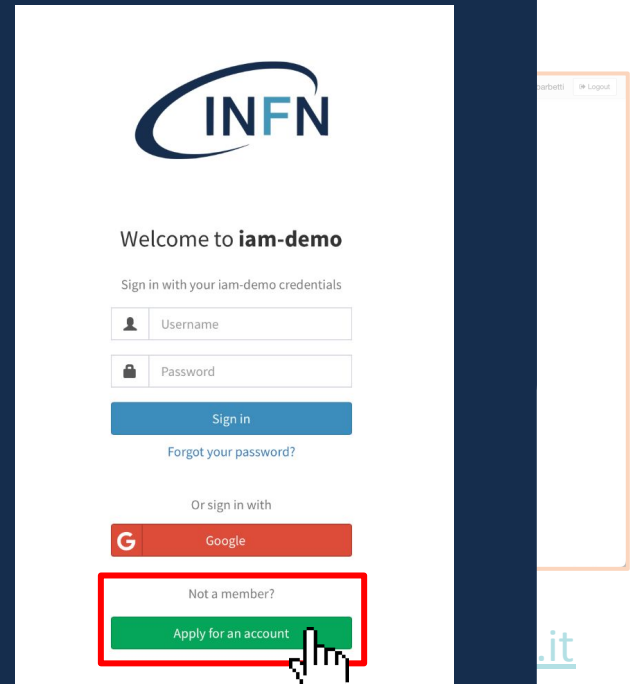
Two AI_INFN-like platforms for the hackathon

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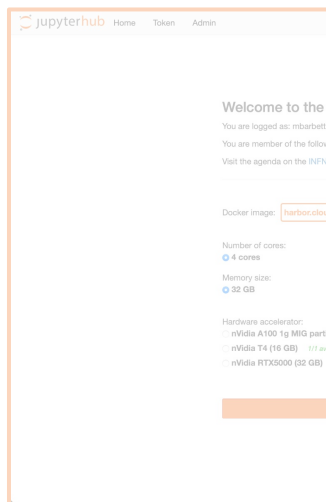
<https://hackathon.ai.cloud.infn.it>



<https://hackathon.ai.cloud.infn.it>

Two AI_INFN-like platforms for the hackathon

To request a new iam-demo account you simply have to fill the form with the needed information

A screenshot of the 'Register at iam-demo' form. At the top is the INFN logo. The title is 'Register at iam-demo'. Below that, it says 'This is the iam-demo registration page. To proceed with the registration please fill in your personal information below.' The form has several fields: 'Given name' (text input), 'Family name' (text input), 'Email' (text input), 'Username' (text input with a dropdown arrow), and 'Notes' (a larger text area). A note below the 'Notes' field says 'Providing a clear explanation on the motivation behind this request will likely speed up the approval process'.

<https://hackathon.ai.cloud.infn.it>



<https://hackathon.ai.cloud.infn.it>

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Two AI_INFN-like platforms for the hackathon

To request a new iam-demo account you simply have to fill the form with the needed information

Important!

Choose a “Username” with lowercase letters only.

Pippo 👎

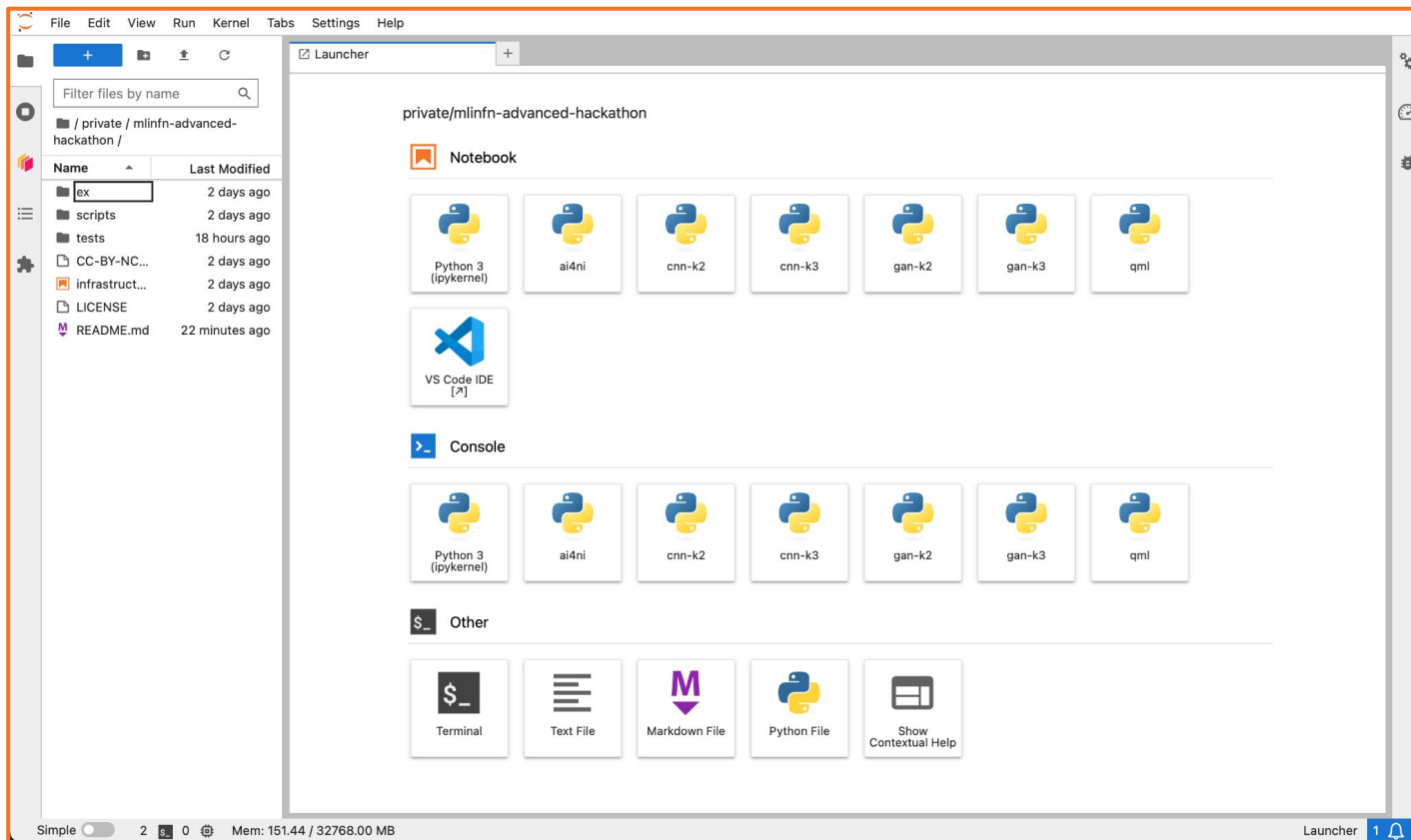
pippo 👎

pippo123 👎

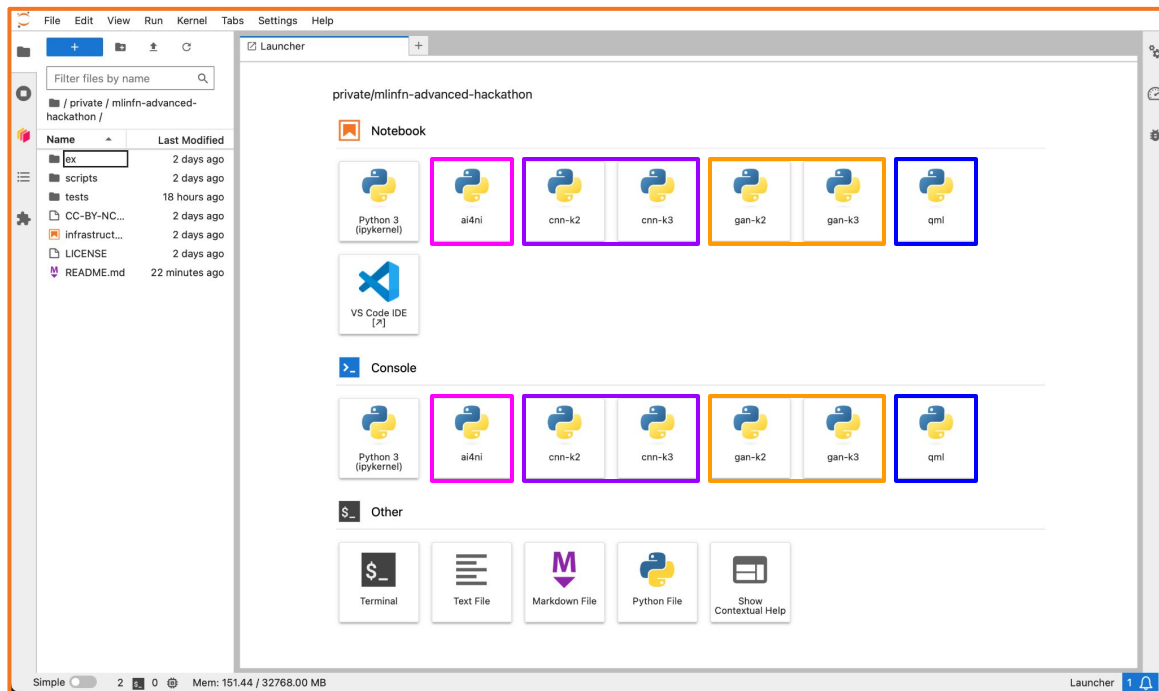
pippo-iam 👎

pippo_pluto 👍

The hackathon platform



Ready-to-use Python environments



- **lhcf-cnn**
 - **cnn-k2** – based on TF2.14 (default)
 - **cnn-k3** – based on TF2.16
- **gan-detector**
 - **gan-k2** – based on TF2.14 (default)
 - **gan-k3** – based on TF2.16
- **asd-diagnosis**
 - **ai4ni** – based on TF2.14
- **quantum-ml**
 - **qml** – powered by PyTorch 2.3, PennyLane 0.36, and Qiskit 1.1

GitHub Repository for hackathon material

- **Official repository:** [landerlini/mlinf-advanced-hackathon](https://github.com/landerlini/mlinf-advanced-hackathon)
 - the same that hosts the materials of the [3rd](#) and [5th](#) ML-INFN Advanced Hackathons
 - it will also host the materials of this [1st](#) AI-INFN Advanced Hackathon
 - its content will be used to prepare the **student homes**
- **Working repository:** [mbarbetti/mlinf-advanced-hackathon](https://github.com/mbarbetti/mlinf-advanced-hackathon)
 - at the moment, the **most updated repository** in terms of exercises and tests
 - its content is based on the materials provided in the AI_INFN Hub (/home/shared/*)
 - pull request ([PR#5](#)) opened to **update the official repository**

Working repository: *organization*

[mbarbetti/mlinfn-advanced-hackathon/ex](#)

```
|— asd-diagnosis
|— gan-detector
|— lhcf-cnn
|— quantum-ml
|— tests
  |— asd-diagnosis
  |— gan-detector
  |— lhcf-cnn
  |— quantum_env.ipynb
  |— quantum-ml
  |— tensorflow_env.ipynb
```

[mbarbetti/mlinfn-advanced-hackathon/tests](#)

```
|— test_advanced_jupyter.py
|— test_notebooks.py
|— working_dir.py
```

Working repository: *lhcf-cnn*

[mbarbetti/mlinfn-advanced-hackathon/ex/lhcf-cnn](https://github.com/mbarbetti/mlinfn-advanced-hackathon/tree/main/ex/lhcf-cnn)

```

├── ex-solution
│   ├── Network.ipynb
│   └── train_and_split.ipynb
├── ex-student
│   ├── Network.ipynb
│   └── train_and_split.ipynb

```

Conda envs:

- **cnn-k2** (default) ✓
- **cnn-k3** ✓

Note: data loading added

```

[1]: %%bash
DATA_DIR=/tmp/lhcf-cnn

if [ ! -d $DATA_DIR ]; then
  mkdir -p $DATA_DIR
fi

if [ ! -f $DATA_DIR/combined_data.h5 ]; then
  wget https://minio.131.154.99.37.myip.cloud.infn.it/hackathon-data/lhcf-cnn/combined_data.h5 -O $DATA_DIR/combined_data.h5
fi

ls -lrth $DATA_DIR/combined_data.h5

-rw-r--r--. 1 root root 5.6G Nov 14 11:37 /tmp/lhcf-cnn/combined_data.h5

```

Working repository: *gan-detector*

[mbarbetti/mlinfn-advanced-hackathon/ex/gan-detector](https://github.com/mbarbetti/mlinfn-advanced-hackathon/ex/gan-detector)

```
├── ex-solution
│   └── Gauss_smearing_GAN.ipynb
└── ex-student
```

Conda envs:

- gan-k2 (default) ✓
- gan-k3 ✗

```
[11]: from tensorflow.keras.optimizers.legacy import Adam

t0 = time.time()
class LSGAN():
    def __init__(self):
        self.latent_dim = 100
        optimizer = Adam(learning_rate=0.0001, beta_1=0.5)

        # Build and compile the discriminator
        self.discriminator = self.build_discriminator()
        self.discriminator.compile(loss='mse',
                                   optimizer=optimizer,
                                   metrics=['accuracy'])

        # Build the generator
        self.generator = self.build_generator()

        generator_noise = Input(shape=(self.latent_dim,))
        Det_events = self.generator(generator_noise)

        # For the combined model we will only train the generator
        self.discriminator.trainable = False

        # The valid takes generated detector_events as input and determines validity
        valid = self.discriminator(Det_events)

        # The combined model (stacked generator and discriminator)---->Trains generator to fool discriminator
        self.combined = Model([generator_noise], valid)

        # (!!!) Optimize w.r.t. MSE loss instead of crossentropy
        # MMD_loss = self.MMD_loss()
        self.combined.compile(loss='mse', optimizer=optimizer)
```

Note: some code updates needed to enable using the Keras 3 conda env (gan-k3)

Working repository: *asd-diagnosis*

[mbarbetti/mlinfn-advanced-hackathon/ex/asd-diagnosis](https://github.com/mbarbetti/mlinfn-advanced-hackathon/tree/main/ex/asd-diagnosis)

```

├── ex-solution
│   ├── Joint_Fusion.ipynb
│   └── sMRI_fmRI_sep.ipynb
└── ex-student

```

Conda envs:

- ai4ni (default) ✓

Note: data loading added

```

[1]: %%bash
DATA_DIR=/tmp/asd-diagnosis

if [ ! -d $DATA_DIR ]; then
  mkdir -p $DATA_DIR
fi

wget https://minio.131.154.99.37.myip.cloud.infn.it/hackathon-data/asd-diagnosis/functional_features.csv -O $DATA_DIR/fu
wget https://minio.131.154.99.37.myip.cloud.infn.it/hackathon-data/asd-diagnosis/Harmonized_structural_features.csv -O $
wget https://minio.131.154.99.37.myip.cloud.infn.it/hackathon-data/asd-diagnosis/Harmonized_functional_features.csv -O $

ls -lrth $DATA_DIR/*

-rw-r--r-- 1 root root 417K Nov 14 10:10 /tmp/asd-diagnosis/functional_features.csv
-rw-r--r-- 1 root root 5.5M Nov 14 10:10 /tmp/asd-diagnosis/Harmonized_structural_features.csv
-rw-r--r-- 1 root root 133M Nov 14 10:12 /tmp/asd-diagnosis/Harmonized_functional_features.csv

```


Working repository: *quantum-ml*

[mbarbetti/mlinfn-advanced-hackathon/ex/quantum-ml](https://github.com/mbarbetti/mlinfn-advanced-hackathon/tree/main/ex/quantum-ml)

```

├── ex-solution
│   ├── QAE_PennyLanePytorch.ipynb
│   ├── QClassifier_PennyLanePytorch.ipynb
│   ├── QClassifier_PennyLanePytorch_multiclass.ipynb
│   └── QUBO_GraphColoring.ipynb
└── ex-student
  
```

Conda envs:

- `qml` (default) ✓

Note: environ vars set to enable PyTorch to run at ReCaS

```

[2]: # import needed libraries
import numpy as np
import matplotlib.pyplot as plt
import os
os.environ["CUDA_VISIBLE_DEVICES"] = "0"
os.environ["WORLD_SIZE"] = "1"

from time import time
from tqdm import tqdm

import torch
import pennylane as qml
print('Torch version: ', torch.__version__)
print('PennyLane version: ', qml.__version__)
  
```

```

Torch version: 2.3.1+cu121
PennyLane version: 0.36.0
  
```

Working repository: *tests*

[mbarbetti/mlinfn-advanced-hackathon/tests](#)

```
├── test_advanced_jupyter.py
├── test_notebooks.py
└── working_dir.py
```

[mbarbetti/mlinfn-advanced-hackathon/ex/tests](#)

```
├── asd-diagnosis
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├── lhcf-cnn
│   └── train_and_split.ipynb
├── quantum_env.ipynb
├── quantum-ml
│   ├── QAE_PennylanePytorch.ipynb
│   ├── QClassifier_PennylanePytorch.ipynb
│   ├── QClassifier_PennylanePytorch_multiclass.ipynb
│   └── QUBO_GraphColoring.ipynb
└── tensorflow_env.ipynb
```

How to run tests?

```
root@jupyter-mbarbetti:/home# cd
root@jupyter-mbarbetti:~# source .bashrc
(base) root@jupyter-mbarbetti:~# pip install pytest
Requirement already satisfied: pytest in /opt/conda/lib/python3.11/site-packages (8.3.3)
Requirement already satisfied: iniconfig in /opt/conda/lib/python3.11/site-packages (from pytest) (2.0.0)
Requirement already satisfied: packaging in /opt/conda/lib/python3.11/site-packages (from pytest) (23.2)
Requirement already satisfied: pluggy<2,>=1.5 in /opt/conda/lib/python3.11/site-packages (from pytest) (1.5.0)
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the
system package manager. It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
(base) root@jupyter-mbarbetti:~# ls -lrt mlinfn-advanced-hackathon/
total 576
-rw-r--r-- 1 root root 20848 Nov 14 16:21 CC-BY-NC-SA-4.0
-rw-r--r-- 1 root root 1067 Nov 14 16:21 LICENSE
-rw-r--r-- 1 root root 536645 Nov 14 16:21 infrastructure_handson.ipynb
drwxr-xr-x 2 root root 4096 Nov 14 16:21 scripts
drwxr-xr-x 8 root root 4096 Nov 14 19:02 ex
-rw-r--r-- 1 root root 6415 Nov 17 14:46 README.md
drwxr-xr-x 3 root root 4096 Nov 17 15:17 tests
(base) root@jupyter-mbarbetti:~# cd mlinfn-advanced-hackathon/
(base) root@jupyter-mbarbetti:~/mlinfn-advanced-hackathon# pytest tests/test_notebooks.py -v --durations=0
```

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(base) root@jupyter-mbarbetti:~/mlinfn-advanced-hackathon# pytest tests/test_notebooks.py -v --durations=0

```

Launch conda init

How to run tests?

Install `pytest` in the
base conda env

```

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root@jupyter-mbarbetti:~# source .bashrc
(base) root@jupyter-mbarbetti:~# pip install pytest
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(base) root@jupyter-mbarbetti:~# ls -lrt mlinfn-advanced-hackathon/
total 576
-rw-r--r-- 1 root root 20848 Nov 14 16:21 CC-BY-NC-SA-4.0
-rw-r--r-- 1 root root 1067 Nov 14 16:21 LICENSE
-rw-r--r-- 1 root root 536645 Nov 14 16:21 infrastructure_handson.ipynb
drwxr-xr-x 2 root root 4096 Nov 14 16:21 scripts
drwxr-xr-x 8 root root 4096 Nov 14 19:02 ex
-rw-r--r-- 1 root root 6415 Nov 17 14:46 README.md
drwxr-xr-x 3 root root 4096 Nov 17 15:17 tests
(base) root@jupyter-mbarbetti:~# cd mlinfn-advanced-hackathon/
(base) root@jupyter-mbarbetti:~/mlinfn-advanced-hackathon# pytest tests/test_notebooks.py -v --durations=0

```

Move in the working repository
(if absent, you should
download it with `git clone`)

How to run tests?

```

root@jupyter-mbarbetti:/home# cd
root@jupyter-mbarbetti:~# source .bashrc
(base) root@jupyter-mbarbetti:~# pip install pytest
Requirement already satisfied: pytest in /opt/conda/lib/python3.11/site-packages (8.3.3)
Requirement already satisfied: iniconfig in /opt/conda/lib/python3.11/site-packages (from pytest) (2.0.0)
Requirement already satisfied: packaging in /opt/conda/lib/python3.11/site-packages (from pytest) (23.2)
Requirement already satisfied: pluggy<2,>=1.5 in /opt/conda/lib/python3.11/site-packages (from pytest) (1.5.0)
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the
system package manager. It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
(base) root@jupyter-mbarbetti:~# ls -lrt mlinfn-advanced-hackathon/
total 576
-rw-r--r-- 1 root root 20848 Nov 14 16:21 CC-BY-NC-SA-4.0
-rw-r--r-- 1 root root 1067 Nov 14 16:21 LICENSE
-rw-r--r-- 1 root root 536645 Nov 14 16:21 infrastructure_handson.ipynb
drwxr-xr-x 2 root root 4096 Nov 14 16:21 scripts
drwxr-xr-x 8 root root 4096 Nov 14 19:02 ex
-rw-r--r-- 1 root root 6415 Nov 17 14:46 README.md
drwxr-xr-x 3 root root 4096 Nov 17 15:17 tests
(base) root@jupyter-mbarbetti:~# cd mlinfn-advanced-hackathon/
(base) root@jupyter-mbarbetti:~/mlinfn-advanced-hackathon# pytest tests/test_notebooks.py -v --durations=0

```

Run the Python tests
 (-v for verbosity,
 --durations=0 to show times)

How to run tests?

```

root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#
root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#
(base) root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#
Requirement already satisfied:
Requirement already satisfied:
Requirement already satisfied:
WARNING: Running pip as the 'root' user
https://pip.pypa.io/en/latest/
(base) root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#
total 576
-rw-r--r-- 1 root
-rw-r--r-- 1 root
-rw-r--r-- 1 root
drwxr-xr-x 2 root
drwxr-xr-x 8 root
-rw-r--r-- 1 root
drwxr-xr-x 3 root
(base) root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#
(base) root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon#

```

```

(base) root@jupyter-mbarbetti:~/m/linfn-advanced-hackathon# python3 -m pytest tests/test_notebooks.py -v --durations=0
===== test session starts =====
platform linux -- Python 3.11.6, pytest-8.3.3, pluggy-1.5.0 -- /opt/conda/bin/python3
cachedir: .pytest_cache
rootdir: /home/private/mlinf-advanced-hackathon
plugins: anyio-4.0.0
collected 14 items

tests/test_notebooks.py::test_env_tensorflow[cnn-k2] PASSED [ 7%]
tests/test_notebooks.py::test_env_tensorflow[cnn-k3] PASSED [ 14%]
tests/test_notebooks.py::test_env_tensorflow[gan-k2] PASSED [ 21%]
tests/test_notebooks.py::test_env_tensorflow[gan-k3] PASSED [ 28%]
tests/test_notebooks.py::test_env_tensorflow[ai4ni] PASSED [ 35%]
tests/test_notebooks.py::test_env_quantum[qml] PASSED [ 42%]
tests/test_notebooks.py::test_ex_lhcf_cnn[cnn-k2] PASSED [ 50%]
tests/test_notebooks.py::test_ex_lhcf_cnn[cnn-k3] PASSED [ 57%]
tests/test_notebooks.py::test_ex_gan_detector[gan-k2] PASSED [ 64%]
tests/test_notebooks.py::test_ex_asd_diagnosis[ai4ni-sMRI_fmri_sep] PASSED [ 71%]
tests/test_notebooks.py::test_ex_asd_diagnosis[ai4ni-sMRI_fmri_sep] PASSED [ 78%]
tests/test_notebooks.py::test_ex_quantum_ml[qml-QClassifier_*] PASSED [ 85%]
tests/test_notebooks.py::test_ex_quantum_ml[qml-QAE_*] PASSED [ 92%]
tests/test_notebooks.py::test_ex_quantum_ml[qml-QUBO_*] PASSED [100%]

===== warnings summary =====
../../../../opt/conda/lib/python3.11/site-packages/jupyter_client/connect.py:20
/opt/conda/lib/python3.11/site-packages/jupyter_client/connect.py:20: DeprecationWarning: Jupyter is migrating its paths to use standard platformdirs
given by the platformdirs library. To remove this warning and
see the appropriate new directories, set the environment variable
`JUPYTER_PLATFORM_DIRS=1` and then run `jupyter --paths`.
The use of platformdirs will be the default in `jupyter_core` v6
from jupyter_core.paths import jupyter_data_dir, jupyter_runtime_dir, secure_write

-- Docs: https://docs.pytest.org/en/stable/how-to/capture-warnings.html
===== slowest durations =====
126.12s call    tests/test_notebooks.py::test_ex_asd_diagnosis[ai4ni-sMRI_fmri_sep]
122.00s call    tests/test_notebooks.py::test_ex_asd_diagnosis[ai4ni-sMRI_fmri_sep]
113.00s call    tests/test_notebooks.py::test_ex_quantum_ml[qml-QClassifier_*]
93.83s call    tests/test_notebooks.py::test_ex_gan_detector[gan-k2]
69.95s call    tests/test_notebooks.py::test_ex_lhcf_cnn[cnn-k3]
65.99s call    tests/test_notebooks.py::test_ex_lhcf_cnn[cnn-k2]
37.87s call    tests/test_notebooks.py::test_ex_quantum_ml[qml-QAE_*]
18.20s call    tests/test_notebooks.py::test_ex_quantum_ml[qml-QUBO_*]
12.03s call    tests/test_notebooks.py::test_env_tensorflow[cnn-k3]
11.55s call    tests/test_notebooks.py::test_env_quantum[qml]
10.76s call    tests/test_notebooks.py::test_env_tensorflow[gan-k3]
10.52s call    tests/test_notebooks.py::test_env_tensorflow[gan-k2]
10.52s call    tests/test_notebooks.py::test_env_tensorflow[cnn-k2]
10.29s call    tests/test_notebooks.py::test_env_tensorflow[ai4ni]

(28 durations < 0.005s hidden. Use -vv to show these durations.)
===== 14 passed, 1 warning in 713.09s (0:11:53) =====

```

tests run on RTX 5000

```

st) (2.0.0)
st) (23.2)
pytest) (1.5.0)
iour with the

```

--durations=0



Questions? Comments?

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