Elaborato_CCS

May 29, 2022

1 Sistema di riconoscimento visivo tramite FuseMedML

1.1 Fase di settaggio dell'ambiente

1.1.1 Montaggio delle cartelle di Google Drive

[ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

1.1.2 Clonazione e installazione della libreria FuseMedML

[ ]:
```
!git clone https://github.com/IBM/fuse-med-ml.git     #clonazione della␣
↪repository delle funzioni di fuse
%cd fuse-med-ml
!pip install -e .                                      #aggiornamento delle␣
↪dipendenze pip per l'elaborazione delle funzioni
```

```
Cloning into 'fuse-med-ml'…
remote: Enumerating objects: 3915, done.
remote: Counting objects: 100% (1154/1154), done.
remote: Compressing objects: 100% (603/603), done.
remote: Total 3915 (delta 607), reused 1011 (delta 533), pack-reused 2761
Receiving objects: 100% (3915/3915), 74.59 MiB | 36.18 MiB/s, done.
Resolving deltas: 100% (2231/2231), done.
/content/fuse-med-ml
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-
wheels/public/simple/
Obtaining file:///content/fuse-med-ml
Requirement already satisfied: numpy>=1.18.5 in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (1.21.6)
Requirement already satisfied: pandas>=1.2 in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (1.3.5)
Requirement already satisfied: tqdm>=4.52.0 in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (4.64.0)
```

```
Collecting scipy>=1.5.4
  Downloading
scipy-1.7.3-cp37-cp37m-manylinux_2_12_x86_64.manylinux2010_x86_64.whl (38.1 MB)
     |                | 38.1 MB 1.3 MB/s
Collecting matplotlib>=3.3.3
  Downloading
matplotlib-3.5.2-cp37-cp37m-manylinux_2_5_x86_64.manylinux1_x86_64.whl (11.2 MB)
     |                | 11.2 MB 50.4 MB/s
Requirement already satisfied: scikit-image>=0.17.2 in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (0.18.3)
Requirement already satisfied: scikit-learn>=0.23.2 in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (1.0.2)
Requirement already satisfied: termcolor>=1.1.0 in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (1.1.0)
Requirement already satisfied: torch>=1.5.0 in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (1.11.0+cu113)
Requirement already satisfied: torchvision>=0.8.1 in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (0.12.0+cu113)
Requirement already satisfied: tensorboard in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (2.8.0)
Collecting SimpleITK>=1.2.0
  Downloading
SimpleITK-2.1.1.2-cp37-cp37m-manylinux_2_12_x86_64.manylinux2010_x86_64.whl
(48.4 MB)
     |                | 48.4 MB 19 kB/s
Collecting wget
  Downloading wget-3.2.zip (10 kB)
Requirement already satisfied: opencv-python<=4.3.0.36 in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (4.1.2.30)
Requirement already satisfied: ipython in /usr/local/lib/python3.7/dist-packages
(from fuse-med-ml==0.1.12) (5.5.0)
Collecting pydicom
  Downloading pydicom-2.3.0-py3-none-any.whl (2.0 MB)
     |                | 2.0 MB 44.4 MB/s
Requirement already satisfied: h5py in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (3.1.0)
Collecting hdf5plugin
  Downloading hdf5plugin-3.3.0-py3-none-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (9.7 MB)
     |                | 9.7 MB 28.0 MB/s
Collecting deepdiff
  Downloading deepdiff-5.8.1-py3-none-any.whl (69 kB)
     |                | 69 kB 9.2 MB/s
Requirement already satisfied: statsmodels in
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (0.10.2)
Requirement already satisfied: nibabel in /usr/local/lib/python3.7/dist-packages
(from fuse-med-ml==0.1.12) (3.0.2)
Requirement already satisfied: pycocotools>=2.0.1 in
```

```
/usr/local/lib/python3.7/dist-packages (from fuse-med-ml==0.1.12) (2.0.4)
Collecting xmlrunner
  Downloading xmlrunner-1.7.7.tar.gz (5.6 kB)
Collecting paramiko
  Downloading paramiko-2.11.0-py2.py3-none-any.whl (212 kB)
     |                 | 212 kB 59.3 MB/s
Requirement already satisfied: tables in /usr/local/lib/python3.7/dist-
packages (from fuse-med-ml==0.1.12) (3.7.0)
Collecting fonttools>=4.22.0
  Downloading fonttools-4.33.3-py3-none-any.whl (930 kB)
     |                 | 930 kB 57.3 MB/s
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python3.7/dist-packages (from matplotlib>=3.3.3->fuse-med-
ml==0.1.12) (0.11.0)
Requirement already satisfied: pyparsing>=2.2.1 in
/usr/local/lib/python3.7/dist-packages (from matplotlib>=3.3.3->fuse-med-
ml==0.1.12) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.7/dist-packages (from matplotlib>=3.3.3->fuse-med-
ml==0.1.12) (2.8.2)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.7/dist-
packages (from matplotlib>=3.3.3->fuse-med-ml==0.1.12) (7.1.2)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.7/dist-
packages (from matplotlib>=3.3.3->fuse-med-ml==0.1.12) (21.3)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.7/dist-packages (from matplotlib>=3.3.3->fuse-med-
ml==0.1.12) (1.4.2)
Requirement already satisfied: typing-extensions in
/usr/local/lib/python3.7/dist-packages (from
kiwisolver>=1.0.1->matplotlib>=3.3.3->fuse-med-ml==0.1.12) (4.2.0)
Requirement already satisfied: pytz>=2017.3 in /usr/local/lib/python3.7/dist-
packages (from pandas>=1.2->fuse-med-ml==0.1.12) (2022.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-
packages (from python-dateutil>=2.7->matplotlib>=3.3.3->fuse-med-ml==0.1.12)
(1.15.0)
Requirement already satisfied: tifffile>=2019.7.26 in
/usr/local/lib/python3.7/dist-packages (from scikit-image>=0.17.2->fuse-med-
ml==0.1.12) (2021.11.2)
Requirement already satisfied: imageio>=2.3.0 in /usr/local/lib/python3.7/dist-
packages (from scikit-image>=0.17.2->fuse-med-ml==0.1.12) (2.4.1)
Requirement already satisfied: PyWavelets>=1.1.1 in
/usr/local/lib/python3.7/dist-packages (from scikit-image>=0.17.2->fuse-med-
ml==0.1.12) (1.3.0)
Requirement already satisfied: networkx>=2.0 in /usr/local/lib/python3.7/dist-
packages (from scikit-image>=0.17.2->fuse-med-ml==0.1.12) (2.6.3)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/usr/local/lib/python3.7/dist-packages (from scikit-learn>=0.23.2->fuse-med-
ml==0.1.12) (3.1.0)
```

```
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-
packages (from scikit-learn>=0.23.2->fuse-med-ml==0.1.12) (1.1.0)
Requirement already satisfied: requests in /usr/local/lib/python3.7/dist-
packages (from torchvision>=0.8.1->fuse-med-ml==0.1.12) (2.23.0)
Collecting ordered-set<4.2.0,>=4.1.0
  Downloading ordered_set-4.1.0-py3-none-any.whl (7.6 kB)
Requirement already satisfied: cached-property in /usr/local/lib/python3.7/dist-
packages (from h5py->fuse-med-ml==0.1.12) (1.5.2)
Requirement already satisfied: setuptools>=18.5 in
/usr/local/lib/python3.7/dist-packages (from ipython->fuse-med-ml==0.1.12)
(57.4.0)
Requirement already satisfied: decorator in /usr/local/lib/python3.7/dist-
packages (from ipython->fuse-med-ml==0.1.12) (4.4.2)
Requirement already satisfied: pygments in /usr/local/lib/python3.7/dist-
packages (from ipython->fuse-med-ml==0.1.12) (2.6.1)
Requirement already satisfied: pickleshare in /usr/local/lib/python3.7/dist-
packages (from ipython->fuse-med-ml==0.1.12) (0.7.5)
Requirement already satisfied: pexpect in /usr/local/lib/python3.7/dist-packages
(from ipython->fuse-med-ml==0.1.12) (4.8.0)
Requirement already satisfied: prompt-toolkit<2.0.0,>=1.0.4 in
/usr/local/lib/python3.7/dist-packages (from ipython->fuse-med-ml==0.1.12)
(1.0.18)
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.7/dist-
packages (from ipython->fuse-med-ml==0.1.12) (5.1.1)
Requirement already satisfied: simplegeneric>0.8 in
/usr/local/lib/python3.7/dist-packages (from ipython->fuse-med-ml==0.1.12)
(0.8.1)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.7/dist-packages
(from prompt-toolkit<2.0.0,>=1.0.4->ipython->fuse-med-ml==0.1.12) (0.2.5)
Collecting pynacl>=1.0.1
  Downloading PyNaCl-1.5.0-cp36-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.
manylinux_2_24_x86_64.whl (856 kB)
     |                  | 856 kB 57.2 MB/s
Collecting bcrypt>=3.1.3
  Downloading bcrypt-3.2.2-cp36-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.
manylinux_2_24_x86_64.whl (62 kB)
     |                  | 62 kB 1.3 MB/s
Collecting cryptography>=2.5
  Downloading cryptography-37.0.2-cp36-abi3-manylinux_2_24_x86_64.whl (4.0 MB)
     |                  | 4.0 MB 30.2 MB/s
Requirement already satisfied: cffi>=1.1 in /usr/local/lib/python3.7/dist-
packages (from bcrypt>=3.1.3->paramiko->fuse-med-ml==0.1.12) (1.15.0)
Requirement already satisfied: pycparser in /usr/local/lib/python3.7/dist-
packages (from cffi>=1.1->bcrypt>=3.1.3->paramiko->fuse-med-ml==0.1.12) (2.21)
Requirement already satisfied: ptyprocess>=0.5 in /usr/local/lib/python3.7/dist-
packages (from pexpect->ipython->fuse-med-ml==0.1.12) (0.7.0)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
/usr/local/lib/python3.7/dist-packages (from requests->torchvision>=0.8.1->fuse-
```

```
med-ml==0.1.12) (1.24.3)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-
packages (from requests->torchvision>=0.8.1->fuse-med-ml==0.1.12) (2.10)
Requirement already satisfied: chardet<4,>=3.0.2 in
/usr/local/lib/python3.7/dist-packages (from requests->torchvision>=0.8.1->fuse-
med-ml==0.1.12) (3.0.4)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.7/dist-packages (from requests->torchvision>=0.8.1->fuse-
med-ml==0.1.12) (2022.5.18.1)
Requirement already satisfied: patsy>=0.4.0 in /usr/local/lib/python3.7/dist-
packages (from statsmodels->fuse-med-ml==0.1.12) (0.5.2)
Requirement already satisfied: numexpr>=2.6.2 in /usr/local/lib/python3.7/dist-
packages (from tables->fuse-med-ml==0.1.12) (2.8.1)
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in
/usr/local/lib/python3.7/dist-packages (from tensorboard->fuse-med-ml==0.1.12)
(0.6.1)
Requirement already satisfied: absl-py>=0.4 in /usr/local/lib/python3.7/dist-
packages (from tensorboard->fuse-med-ml==0.1.12) (1.0.0)
Requirement already satisfied: werkzeug>=0.11.15 in
/usr/local/lib/python3.7/dist-packages (from tensorboard->fuse-med-ml==0.1.12)
(1.0.1)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in
/usr/local/lib/python3.7/dist-packages (from tensorboard->fuse-med-ml==0.1.12)
(1.8.1)
Requirement already satisfied: protobuf>=3.6.0 in /usr/local/lib/python3.7/dist-
packages (from tensorboard->fuse-med-ml==0.1.12) (3.17.3)
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.7/dist-
packages (from tensorboard->fuse-med-ml==0.1.12) (3.3.7)
Requirement already satisfied: wheel>=0.26 in /usr/local/lib/python3.7/dist-
packages (from tensorboard->fuse-med-ml==0.1.12) (0.37.1)
Requirement already satisfied: google-auth<3,>=1.6.3 in
/usr/local/lib/python3.7/dist-packages (from tensorboard->fuse-med-ml==0.1.12)
(1.35.0)
Requirement already satisfied: grpcio>=1.24.3 in /usr/local/lib/python3.7/dist-
packages (from tensorboard->fuse-med-ml==0.1.12) (1.46.1)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in
/usr/local/lib/python3.7/dist-packages (from tensorboard->fuse-med-ml==0.1.12)
(0.4.6)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/usr/local/lib/python3.7/dist-packages (from google-
auth<3,>=1.6.3->tensorboard->fuse-med-ml==0.1.12) (0.2.8)
Requirement already satisfied: cachetools<5.0,>=2.0.0 in
/usr/local/lib/python3.7/dist-packages (from google-
auth<3,>=1.6.3->tensorboard->fuse-med-ml==0.1.12) (4.2.4)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.7/dist-
packages (from google-auth<3,>=1.6.3->tensorboard->fuse-med-ml==0.1.12) (4.8)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/usr/local/lib/python3.7/dist-packages (from google-auth-
```

```
oauthlib<0.5,>=0.4.1->tensorboard->fuse-med-ml==0.1.12) (1.3.1)
Requirement already satisfied: importlib-metadata>=4.4 in
/usr/local/lib/python3.7/dist-packages (from markdown>=2.6.8->tensorboard->fuse-
med-ml==0.1.12) (4.11.3)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-
packages (from importlib-metadata>=4.4->markdown>=2.6.8->tensorboard->fuse-med-
ml==0.1.12) (3.8.0)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in
/usr/local/lib/python3.7/dist-packages (from pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard->fuse-med-ml==0.1.12) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.7/dist-
packages (from requests-oauthlib>=0.7.0->google-auth-
oauthlib<0.5,>=0.4.1->tensorboard->fuse-med-ml==0.1.12) (3.2.0)
Building wheels for collected packages: wget, xmlrunner
  Building wheel for wget (setup.py) … done
  Created wheel for wget: filename=wget-3.2-py3-none-any.whl size=9675
sha256=03e20179f6fad09f82a2b227591516269f37e0c720feb7853246a1825eeff04a
  Stored in directory: /root/.cache/pip/wheels/a1/b6/7c/0e63e34eb06634181c63adac
ca38b79ff8f35c37e3c13e3c02
  Building wheel for xmlrunner (setup.py) … done
  Created wheel for xmlrunner: filename=xmlrunner-1.7.7-py3-none-any.whl
size=6233
sha256=8c1d22b6cf78d2111305095a7088386ce5a06144f6411dd02a447256e25ebc13
  Stored in directory: /root/.cache/pip/wheels/bb/ae/64/7394a8365bd8e7bf4c49b01d
80c0260d1c1ec975183ac1ce37
Successfully built wget xmlrunner
Installing collected packages: fonttools, scipy, pynacl, ordered-set,
matplotlib, cryptography, bcrypt, xmlrunner, wget, SimpleITK, pydicom, paramiko,
hdf5plugin, deepdiff, fuse-med-ml
  Attempting uninstall: scipy
    Found existing installation: scipy 1.4.1
    Uninstalling scipy-1.4.1:
      Successfully uninstalled scipy-1.4.1
  Attempting uninstall: matplotlib
    Found existing installation: matplotlib 3.2.2
    Uninstalling matplotlib-3.2.2:
      Successfully uninstalled matplotlib-3.2.2
  Running setup.py develop for fuse-med-ml
ERROR: pip's dependency resolver does not currently take into account all
the packages that are installed. This behaviour is the source of the following
dependency conflicts.
albumentations 0.1.12 requires imgaug<0.2.7,>=0.2.5, but you have imgaug 0.2.9
which is incompatible.
Successfully installed SimpleITK-2.1.1.2 bcrypt-3.2.2 cryptography-37.0.2
deepdiff-5.8.1 fonttools-4.33.3 fuse-med-ml-0.1.12 hdf5plugin-3.3.0
```

```
matplotlib-3.5.2 ordered-set-4.1.0 paramiko-2.11.0 pydicom-2.3.0 pynacl-1.5.0
scipy-1.7.3 wget-3.2 xmlrunner-1.7.7
```

1.1.3 Import di Librerie Python e Fuse

[ ]:
```
import os
from typing import OrderedDict

import torch
import torch.nn.functional as F
import torch.optim as optim
import torchvision
from torch.utils.data.dataloader import DataLoader
from torchvision import transforms, datasets
from sklearn.model_selection import train_test_split

from fuse.eval.evaluator import EvaluatorDefault
from fuse.data.dataset.dataset_wrapper import FuseDatasetWrapper
from fuse.data.sampler.sampler_balanced_batch import FuseSamplerBalancedBatch
from fuse.losses.loss_default import FuseLossDefault
from fuse.managers.callbacks.callback_tensorboard import FuseTensorboardCallback
from fuse.managers.manager_default import FuseManagerDefault
from fuse.eval.metrics.classification.metrics_classification_common import␣
 ↪MetricAccuracy, MetricAUCROC, MetricROCCurve, MetricAUCPR,␣
 ↪MetricConfusionMatrix, MetricBSS
from fuse.eval.metrics.classification.metrics_thresholding_common import␣
 ↪MetricApplyThresholds
from fuse.models.model_wrapper import FuseModelWrapper
from fuse_examples.tutorials.hello_world.hello_world_utils import LeNet,␣
 ↪perform_softmax
from fuse.data.augmentor.augmentor_toolbox import aug_image_default_pipeline
```

1.1.4 Definizione dei path di output

[ ]:
```
ROOT = 'CCS' # Cartella che conterrà tutti i file necessari al funzionamento␣
 ↪della rete
PATHS = {'model_dir': os.path.join(ROOT, 'T1VOL/model_dir'),
         'force_reset_model_dir': True,  # Se impostato a True il path␣
 ↪contenente il modello verrà ripristinato automaticamente -
                                         # altrimenti è necessario ogni volta␣
 ↪confermare l'operazione di ripristino tramite comando.
         'cache_dir': os.path.join(ROOT, 'T1VOL/cache_dir'),
         'inference_dir': os.path.join(ROOT, 'T1VOL/infer_dir'),
         'eval_dir': os.path.join(ROOT, 'T1VOL/eval_dir')}
```

```
paths = PATHS
```

1.2 Fase di settaggio dei parametri di addestramento

1.2.1 Parametri generici di addestramento

All'interno della libreria Fuse, è necessario settare alcune tipoligie obbligatorie di parametri, tra cui si possono distinguere tre differenti classi: * Parametri di tipo **Model** - che tipo di modello si utilizza. * Parametri di tipo **Data** - definisce i parametri per il preprocessing. * Parametri di tipo **Manager** - definisce i parametri per il training.

[ ]:
```
TRAIN_COMMON_PARAMS = {}

### Model ###
TRAIN_COMMON_PARAMS['model'] = 'vgg11'                    #modello scelto: VGG11

### Data ###
TRAIN_COMMON_PARAMS['data.batch_size'] = 70               #dimensione di ogni␣
↪batch
TRAIN_COMMON_PARAMS['data.train_num_workers'] = 8         #numero di worker␣
↪della rete durante il training
TRAIN_COMMON_PARAMS['data.validation_num_workers'] = 8    #numero di worker␣
↪della rete durante la validazione

### Manager ###
TRAIN_COMMON_PARAMS['manager.train_params'] = {
    'device': 'cuda',                 # device, si prende la scheda video
    'num_epochs': 40,                 # numero di epoche durante la fase di␣
↪training
    'virtual_batch_size': 1,          # numero di batch in un batch virtuale:␣
↪in questo caso la mappatura è 1:1
    'start_saving_epochs': 5,         # prima epoca da cui comincio a salvare i␣
↪pesi
    'gap_between_saving_epochs': 2,   # numero di epoche tra ogni checkpoint di␣
↪pesi
                                      # ogni 5 epoche salvo i pesi della rete,␣
↪partendo dall'epoca n.10
}
TRAIN_COMMON_PARAMS['manager.best_epoch_source'] = {
    'source': 'metrics.accuracy',     # si sceglie la metrica di valutazione␣
↪dal dizionario 'epoch_result': in questo caso Accuracy
    'optimization': 'max',            # si sceglie l'obiettivo per tale␣
↪metrica, in questo caso si vuole massimizzare l'accuracy
    'on_equal_values': 'better',      # si sceglie che cosa fare in␣
↪corrispondenza di valori di accuracy uguali nella best epoch,
```

```
                                    # in questo caso si prende la 'better',␣
↪ma potevo scegliere anche 'worst'
}
TRAIN_COMMON_PARAMS['manager.learning_rate'] = 0.0001               #si␣
↪definisce il learning rate
TRAIN_COMMON_PARAMS['manager.weight_decay'] = 0.001                 #si␣
↪definisce il decay dei pesi della rete
TRAIN_COMMON_PARAMS['manager.resume_checkpoint_filename'] = None    # Messo a␣
↪None prova a ripristinare il checkpoint

TRAIN_COMMON_PARAMS['manager.train_params']['device'] = 'cuda'   # si sceglie␣
↪il device su cui eseguire la rete

train_params = TRAIN_COMMON_PARAMS
```

Dimensione virtuale dei batch Per i modelli le cui prestazioni sono limitate dalla memoria della GPU, e quindi dalla dimensione dei batch - molti modelli NLP, in particolare, hanno questo problema - questa semplice tecnica offre un modo semplice per ottenere una dimensione "virtuale" dei batch più grande di quella che si adatta alla memoria. Per esempio, se è possibile inserire solo 16 campioni per batch nella memoria della GPU, è possibile inoltrare due batch, poi passare all'indietro una volta, per una dimensione effettiva di 32 batch. Oppure passare avanti quattro volte, passare indietro una volta, per una dimensione del batch di 64. E così via. Questo è possibile impostarlo tramite fuse variando il parametro 'virtual_batch_size', che indica il numero di batch effettivi da includere all'interno di un batch virtuale

Decadimento dei pesi Il parametro 'weight_decay' serve a stabilire un coefficiente di penalità per il learning rate. Questo parametro viene aggiunto alla loss calcolata al passo precedente, moltiplicando tale fattore per la norma quadra dei pesi precedente. In sostanza, viene usata la formula:

$$loss(i) = loss(i-1) + WD * ||weights||^2$$

1.3 Fase di processing dei dati

Si vanno a convertire in dataloaders tutti i dati presenti, sfruttanto la funzione di pytorch (`torch.utils.data.DataLoader`) sia per la parte di validation che per la parte di training usando i seguenti componenti Fuse: 1. Wrapper - **FuseDatasetWrapper**: Raccoglie il dataset convertito in DataLoader in un dizionario tale che sia mappato con le etichette date in input. 2. Sampler - **FuseSamplerBalancedBatch**: Implementa semplicemente il sampler di Pytorch 'torch.utils.data.sampler'. Tale sampler crea dei batch bilanciati tra le classi, comprendendo un uguale numero di samples per ogni classe all'interno del batch.

[ ]:
```
transform = transforms.Compose([                                #si va a definire una␣
↪trasformazione in tensori
    transforms.Resize((224,224)),                               #si ridefinisce la␣
↪dimensione dell'immagine
```

```
    transforms.ToTensor(),                                  #si attua la␣
 ↪trasformazione in tensore
    transforms.Normalize((0.1307,), (0.3081,))              #si applica una␣
 ↪normalizzazione secondo dei pesi prefissati
])
```

[ ]:
```
!pip install split-folders                                                  ␣
 ↪            #libreria per l'installazione della funzioni di split
import splitfolders

data_dir = '/content/drive/MyDrive/DATI/T1VOL'                              ␣
 ↪           #directory contenente i dati da partizionare
splitfolders.ratio(data_dir, output="content/DATASET", seed=1337, ratio=(.6, 0.
 ↪2, 0.2))     #creazione dello split con la definizione delle percentuali
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-
wheels/public/simple/
Collecting split-folders
  Downloading split_folders-0.5.1-py3-none-any.whl (8.4 kB)
Installing collected packages: split-folders
Successfully installed split-folders-0.5.1

Copying files: 2264 files [00:29, 77.35 files/s]
```

[ ]:
```
# si definisce il wrapping come descritto prima per il dataset di training,␣
 ↪mappando il dataset con un dizionario che contiene 'immagine' e 'etichetta'
data_dir = 'content/DATASET'

#============================================================================================
#                                          TRAINING DATASET
#============================================================================================

torch_train_dataset = {x: datasets.ImageFolder(os.path.join(data_dir, x),␣
 ↪transform) for x in ['train', 'val']}
train_dataset = FuseDatasetWrapper(name='train',␣
 ↪dataset=torch_train_dataset['train'], mapping=('image', 'label'))

# si procede a creare il dataset wrappato
train_dataset.create()

# si definisce il sampler per la creazione dei batch bilanciati di Fuse
sampler = FuseSamplerBalancedBatch(dataset=train_dataset,                   ␣
 ↪#si fornisce in input il dataset da cui creare i batch
                                   balanced_class_name='data.label',        ␣
 ↪#si definisce l'etichetta secondo la quale si effettua il bilanciamento
                                   num_balanced_classes=2,                  ␣
 ↪#si imposta il numero di classi da bilanciare
```

```
                                    batch_size=train_params['data.batch_size'],␣
↪#dimensione del batch, che avendo messo none al parametro di dopo voglio che␣
↪sia diviso per il num_balanced_classes
                                    balanced_class_weights=None)                ␣
↪#mettendo None dico che voglio un numero di classi uguale per ogni batch,␣
↪altrimenti è un intero
                                                                                ␣
↪#che definisce quanti campioni di ogni classe vanno in un batch

# Creo il dataloader con la funzione apposita di pytorch
train_dataloader = DataLoader(dataset=train_dataset, batch_sampler=sampler,␣
↪num_workers=train_params['data.train_num_workers'])


#============================================================================================
#                                          VALIDATION DATASET
#============================================================================================


# faccio il wrapping con la funzione di fuse
validation_dataset = FuseDatasetWrapper(name='validation',␣
↪dataset=torch_train_dataset['val'], mapping=('image', 'label'))
validation_dataset.create()

# e creo il dataloader con pytorch
validation_dataloader = DataLoader(dataset=validation_dataset,␣
↪batch_size=train_params['data.batch_size'],
                                    num_workers=train_params['data.
↪validation_num_workers'])
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
```

1.4 Fase di definizione del modello

Si construisce ora la rete VGG11 usando PyTorch e poi se ne fa il wrapping usando le funzioni di Fuse. Il modello di output sarà aggregato in un dizionario chiamato `batch_dict['model.*']`.

[ ]:
```
from torchvision.models import vgg11
```

```
torch_model = vgg11(pretrained = True)
 ↪            #prendo il modello di VGG11 preaddestrata

model = FuseModelWrapper(model=torch_model,
 ↪             #modello di cui si vuole fare il wrapping
                        model_inputs=['data.image'],
 ↪             #sequenza di chiavi nel dizionario dei batch da trasferire alla
 ↪funzione model.forward
                        post_forward_processing_function=perform_softmax,
 ↪             #si sceglie di effettuare una elaborazione di forwarding di
 ↪tipo SoftMax, usando la funzione apposita
                        model_outputs=['logits.classification', 'output.
 ↪classification']     #chiavi del dizionario dei batch in cui vado a mettere
 ↪l'output del modello
                        )
```

```
Downloading: "https://download.pytorch.org/models/vgg11-8a719046.pth" to
/root/.cache/torch/hub/checkpoints/vgg11-8a719046.pth

  0%|          | 0.00/507M [00:00<?, ?B/s]
```

1.4.1 Stampa della conformazione della rete convoluzionale

[ ]:
```
torch_model
```

[ ]:
```
VGG(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
    (3): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (4): ReLU(inplace=True)
    (5): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
    (6): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (7): ReLU(inplace=True)
    (8): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (9): ReLU(inplace=True)
    (10): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
    (11): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (12): ReLU(inplace=True)
    (13): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (14): ReLU(inplace=True)
```

```
    (15): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
    (16): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (17): ReLU(inplace=True)
    (18): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (19): ReLU(inplace=True)
    (20): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (avgpool): AdaptiveAvgPool2d(output_size=(7, 7))
  (classifier): Sequential(
    (0): Linear(in_features=25088, out_features=4096, bias=True)
    (1): ReLU(inplace=True)
    (2): Dropout(p=0.5, inplace=False)
    (3): Linear(in_features=4096, out_features=4096, bias=True)
    (4): ReLU(inplace=True)
    (5): Dropout(p=0.5, inplace=False)
    (6): Linear(in_features=4096, out_features=1000, bias=True)
  )
)
```

1.5 Fase di creazione della funzione di Loss

Si crea ora un dizionario di elementi di loss, dove ogni elemento è una classe di tipo FuseLossBase.

Il loss totale è calcolato come somma pesata di tutti gli elementi di tale dizionario.

L'API Fuse estrae la predizione del modello e l'etichetta dal dizionario e poi applica una funzione di calcolo del loss considerandone i pesi definiti dall'utente.

[ ]:
```
losses = {'cls_loss': FuseLossDefault(pred_name='model.logits.classification', ␣
 ↪    #si definisce l'etichetta delle predizioni
                                       target_name='data.label',               ␣
 ↪    #si sceglie il nome della colonna target
                                       callable=F.cross_entropy,               ␣
 ↪    #si imposta la funzione di pytorch di calcolo del loss
                                       weight=1.0)                             ␣
 ↪    #valore da moltiplicare ai pesi finali per computare il loss totale
                                                                               ␣
 ↪    #serve per dare un peso maggiore ai loss calcolati mano mano durante il␣
 ↪processo
}
```

1.6 Fase di definizione delle metriche di addestramento

Si crea un dizionario di elementi, in cui ogni elemento è un metrica definita come oggetto della classe FuseMatricBase.

Le metriche sono calcolate per ogni epoca, sia per la validation che per la fase di addestramento.

La 'best_epoch_source', serve a salvare il miglior modello ottenuto durante la fase di train basandosi sulle metriche che vengono definite.

[ ]:
```
metrics = OrderedDict([
    # definisco la soglia da usare per la classificazione, se impostato così si␣
↪fa ArgMax, con le probabilità
    ('operation_point', MetricApplyThresholds(pred='model.output.
↪classification')),                          #pred: parametro che definisce il␣
↪nome della chiave nel vettore degli score delle predizioni
                                                                                ␣
↪                            #class_names: nomi delle classi. Questo␣
↪parametro è richiesto se si fa un problema multiclasse
    #creo l'oggetto Accuracy
    ('accuracy', MetricAccuracy(pred='results:metrics.operation_point.
↪cls_pred',        #chiave delle predizioni da collezionare su cui fare il␣
↪calcolo
                                target='data.label'))                           ␣
↪        #chiave della classe target su cui calcolare l'accuracy
])
```

1.7 Fase di creazione degli oggetti Callbacks

Definisco i callbacks come oggetti della classe FuseCallbackBase

Un **callback** è un oggetto che fa varie azioni durante i passi del training.

Ad ogni step è possibile infatti fare delle manipolazioni dei dati, del dizionario dei batch batch_dict, o dei risultati di ogni epoca epoch_results.

[ ]:
```
callbacks = [
    FuseTensorboardCallback(model_dir=paths['model_dir']),  # la funzione serve␣
↪per salvare le statistiche di train e validation in dei file di log di tensor
                                                            # detti␣
↪tensorboard. Devo definire solo il path in cui vengono salvate le cose
]
```

1.8 Fase di addestramento della rete

Si va a costruire un manager di Fuse, e si correda tale manager di ottimizzatori e di scheduler presi dalla libreria Pytorch.

I possibili workflow da seguire sono nella documentazione della classe FuseManagerDefault.

Si nota che il manager usa i parametri di training che abbiamo settato in precedenza.

[ ]:
```
# Creo l'ottimizzatore usando Adam, dando in input i parametri del modello, il␣
 ↪learning rate e i pesi
optimizer = optim.Adam(model.parameters(), lr=train_params['manager.
 ↪learning_rate'], weight_decay=train_params['manager.weight_decay'])

# creo lo scheduler sull'ottimizzatore per ridurre il learning rate quando il␣
 ↪modello smette di migliorarsi
# lo scheduler vede se l'ottimizzatore migliora, altrimenti abbassa il learing␣
 ↪rate e da un miglioramento più fine alla rete
scheduler = optim.lr_scheduler.ReduceLROnPlateau(optimizer)

# tdefinisco il Manager di Fuse, per la gestione dei processi di train e di␣
 ↪validation. In questo caso si sta facendo un train by scratch
manager = FuseManagerDefault(output_model_dir=paths['model_dir'],          ␣
 ↪#path della directory del modello
                             force_reset=paths['force_reset_model_dir'])    #se␣
 ↪è True la directory si ripristina in automatico
                                                                            #se␣
 ↪è False, cioè di default, la directory va resettata manualmente

#=============================================================================================
# I POSSIBILI WORKFLOW DATI DAL MANAGER SONO I SEGUENTI:
#
#     Per l'addestramento:
#         FuseManagerDefault() -> manager.set_objects() -> manager.train()
#     Per riprendere l'addestramento da un checkpoint:
#         FuseManagerDefault() -> manager.load_objects() -> manager.
 ↪load_checkpoint() -> manager.train()
#     Per l'addestramento partendo da un modello pre-esistente:
#         FuseManagerDefault() -> manager.set_objects() [-> manager.
 ↪load_objects()] [-> manager.load_checkpoint()] -> manager.train()
#     Per la fase di inferenza:
#         FuseManagerDefault() -> manager.infer()
#         or -
#         FuseManagerDefault() -> manager.load_objects() -> manager.
 ↪load_checkpoint() -> manager.infer()
#     Per la fase di inferenza dato un modello:
#         FuseManagerDefault() -> manager.set_objects() -> manager.
 ↪load_checkpoint() -> manager.infer()
#=============================================================================================


# Impostiamo il manager per lavorare con gli oggetti che abbiamo creato:
```

```
manager.set_objects(net=model,                                                  ␣
 ↪    #modello in input
                    optimizer=optimizer,                                        ␣
 ↪    #ottimizzatore
                    losses=losses,                                              ␣
 ↪    #definizione delle funzioni di loss
                    metrics=metrics,                                            ␣
 ↪    #dizionario delle metriche da elaborare per ogni batch
                    best_epoch_source=train_params['manager.
↪best_epoch_source'],    #metriche usate per decidere la best epoch. Può␣
↪essere anche una lista che contiene le chiavi:
                                                                                ␣
 ↪    #   'source': nome della metrica di loss- e.g. losses.cls_loss or␣
↪metrics.auc
                                                                                ␣
 ↪    #   'optimization': l'ottimizzazione da fare sulla metrica, massimizzare␣
↪o minimizzare.
                                                                                ␣
 ↪    #   'on_equal_values': che cosa fare in caso di valori uguali di epoca,␣
↪prendere il migliore(best) o il peggiore(worse)
                    lr_scheduler=scheduler,                                     ␣
 ↪    #funzione di scheduling
                    callbacks=callbacks,                                        ␣
 ↪    #eventuali callback che voglio fare, nel nostro caso salvare i pesi
                    train_params=train_params['manager.train_params'])          ␣
 ↪    #set di parametri di training che ho definito in un dizionario prima

# FUNZIONE CHE ESEGUE L'ADDESTRAMENTO DELLA RETE PASSANDOGLI IL DATASET DI␣
 ↪TRAIN E DI VALIDATION SU CUI CALCOLARE LE METRICHE
manager.train(train_dataloader=train_dataloader,␣
 ↪validation_dataloader=validation_dataloader)
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 7/7 [00:10<00:00,  1.53s/it]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
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```

```
  cpuset_checked))
100%|      | 24/24 [00:23<00:00,  1.00it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
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  cpuset_checked))
100%|      | 7/7 [00:06<00:00,  1.12it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
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100%|      | 24/24 [00:25<00:00,  1.08s/it]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
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```
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/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
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```
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100%|      | 24/24 [00:24<00:00,  1.01s/it]
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100%|      | 7/7 [00:06<00:00,  1.13it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 24/24 [00:24<00:00,  1.03s/it]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 7/7 [00:06<00:00,  1.12it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
```

```
  cpuset_checked))
100%|      | 24/24 [00:24<00:00,  1.02s/it]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 7/7 [00:06<00:00,  1.04it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 24/24 [00:23<00:00,  1.02it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
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  cpuset_checked))
100%|      | 7/7 [00:06<00:00,  1.13it/s]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 24/24 [00:24<00:00,  1.02s/it]
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490:
UserWarning: This DataLoader will create 8 worker processes in total. Our
suggested max number of worker in current system is 2, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
100%|      | 7/7 [00:06<00:00,  1.04it/s]
```

1.9 Fase di inferenza

Una volta addestrata la rete, voglio i suoi migliori parametri per testare la rete su un test set locale, per valutare la capacità di generalizzazione della rete stessa.

1.9.1 Definizione dei parametri di inferenza

[ ]:
```
INFER_COMMON_PARAMS = {}
INFER_COMMON_PARAMS['infer_filename'] = 'validation_set_infer.gz'
INFER_COMMON_PARAMS['checkpoint'] = 'best'


infer_common_params = INFER_COMMON_PARAMS
```

1.9.2 Processo di inferenza

[ ]:
```
# prendo dei pezzi dal validation per fare il test locale
torch_test_dataset = {'test': datasets.ImageFolder(os.path.join(data_dir,␣
 ↪'test'), transform)}

test_dataset = FuseDatasetWrapper(name='test',␣
 ↪dataset=torch_test_dataset['test'], mapping=('image', 'label'))
# si procede a creare il dataset wrappato
test_dataset.create()

test_dataloader = DataLoader(dataset=test_dataset, collate_fn=test_dataset.
 ↪collate_fn, batch_size=2, num_workers=2)

# creo un manager Fuse per fare le operazioni di inferenza
manager = FuseManagerDefault()
# definisco le colonne che mi servono per l'output
output_columns = ['model.output.classification', 'data.label']

# FUNZIONE CHE ESEGUE IL PROCESSO DI INFERENZA SUI DATI
manager.infer(data_loader=test_dataloader,                                    ␣
 ↪                            #definizione del dataset di inferenza
                input_model_dir=paths['model_dir'],                           ␣
 ↪                            #path del modello da dove devo prendere i␣
 ↪dati
                checkpoint=infer_common_params['checkpoint'],                 ␣
 ↪                            #definisco da dove devo prendere i pesi␣
 ↪della rete
                output_columns=output_columns,                                ␣
 ↪                            #scelgo le colonne che devo restituire in␣
 ↪output
                output_file_name=os.path.join(paths["inference_dir"],␣
 ↪infer_common_params["infer_filename"]))    #path dove vanno a finire gli␣
 ↪output
```

```
100%|      | 227/227 [00:06<00:00, 32.52it/s]
```

[ ]:
```
      descriptor           id  \
0      (test, 0)    (test, 0)
1      (test, 1)    (test, 1)
2      (test, 2)    (test, 2)
3      (test, 3)    (test, 3)
4      (test, 4)    (test, 4)
..           …          …
449  (test, 449)  (test, 449)
450  (test, 450)  (test, 450)
451  (test, 451)  (test, 451)
452  (test, 452)  (test, 452)
453  (test, 453)  (test, 453)

                          model.output.classification  data.label
0    [0.99999917, 2.1591481e-07, 2.3864287e-11, 2.2…           0
1    [0.9999995, 2.2115915e-07, 9.6838666e-12, 9.01…           0
2    [0.9999999, 3.23253e-08, 1.5215458e-12, 1.4138…           0
3    [0.99999607, 3.1012526e-06, 5.3519227e-11, 4.5…           0
4    [0.9999765, 2.1153464e-05, 1.919223e-10, 1.655…           0
..                                                 …          …
449  [1.4600917e-06, 0.99999845, 1.2417709e-10, 9.4…           1
450  [1.0245627e-05, 0.99998975, 4.740749e-12, 4.04…           1
451  [0.000512005, 0.999488, 1.5353308e-12, 1.16443…           1
452  [3.101214e-06, 0.9999969, 2.7139688e-11, 1.885…           1
453  [5.1900224e-05, 0.9999453, 3.6833243e-09, 2.97…           1

[454 rows x 4 columns]
```

1.10 Fase di valutazione delle performance

Uso la classe Evaluator per la valutazione delle performance. Non è necessario che il modello sia di Fuse per usare questa classe.

1.10.1 Definizione dei parametri di valutazione

[ ]:
```
EVAL_COMMON_PARAMS = {}
EVAL_COMMON_PARAMS['infer_filename'] = INFER_COMMON_PARAMS['infer_filename']
eval_common_params = EVAL_COMMON_PARAMS
```

1.10.2 Definizione delle metriche di valutazione

[ ]:
```
# definisco le classi su cui calcolare le metriche

class_names = ['volGBM', 'volMET']

# Definizione delle metriche come dizionario
metrics = OrderedDict([
    ('operation_point', MetricApplyThresholds(pred='model.output.
↪classification')), # come fatto in precedenza si applica ArgMax
    ('accuracy', MetricAccuracy(pred='results:metrics.operation_point.
↪cls_pred', target='data.label')), # definizione dell'accuracy come classe ,␣
↪come fatto prima
    ('roc', MetricROCCurve(pred='model.output.classification',          #creo␣
↪una curva ROC per la valutazione e la salvo in un immagine
                           target='data.label',
                           class_names=class_names,
                           output_filename=os.path.join(paths['inference_dir'],␣
↪'roc_curve.png'))),
    ('auc', MetricAUCROC(pred='model.output.classification',        # definisco␣
↪la metrica AUC sulla cuva ROC
                         target='data.label',
                         class_names=class_names)),
    ('aucpr', MetricAUCPR(pred='model.output.classification',
                                target='data.label',
                                class_names=class_names)),
    ('brier-skill', MetricBSS(pred='model.output.classification',
                                target='data.label'))
])
```

1.10.3 Processo di valutazione e visualizzazione dei risultati

[ ]:
```
# creo la classe Evaluator
evaluator = EvaluatorDefault()

# FUNZIONE CHE ESEGUE IL PROCESSO DI EVALUATION SUI DATI
results = evaluator.eval(ids=None,
                data=os.path.join(paths["inference_dir"],␣
↪eval_common_params["infer_filename"]),
                metrics=metrics,
                output_dir=paths['eval_dir'])
```

```
Results:

Metric operation_point:
-----------------------------------------------
```

```
cls_pred:
<fuse.eval.metrics.utils.PerSampleData object at 0x7f3b72697850>

Metric accuracy:
------------------------------------------------
0.9537444933920705

Metric roc:
------------------------------------------------
volGBM.fpr:
[0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.00552486 0.00552486
 0.00552486 0.00552486 0.01104972 0.01104972 0.01657459 0.01657459
 0.02209945 0.02209945 0.02762431 0.02762431 0.03314917 0.03314917
 0.0441989  0.0441989  0.04972376 0.04972376 0.06077348 0.06077348
 0.06629834 0.06629834 0.0718232  0.0718232  0.08287293 0.08287293
 0.09392265 0.09392265 0.09944751 0.09944751 0.11049724 0.11049724
 0.12707182 0.12707182 0.14364641 0.14364641 0.15469613 0.15469613
 0.68508287 0.6961326  1.        ]
volGBM.tpr:
[0.         0.16849817 0.25274725 0.2967033  0.33333333 0.37728938
 0.3956044  0.41025641 0.41758242 0.44322344 0.45787546 0.47985348
 0.49084249 0.50915751 0.52380952 0.53846154 0.54212454 0.56410256
 0.57142857 0.58608059 0.60805861 0.61904762 0.62637363 0.63003663
 0.63736264 0.64835165 0.65567766 0.67032967 0.67032967 0.68498168
 0.69230769 0.73992674 0.73992674 0.78021978 0.78021978 0.8974359
 0.8974359  0.91575092 0.91575092 0.91941392 0.91941392 0.92673993
 0.92673993 0.94505495 0.94505495 0.95970696 0.95970696 0.96336996
 0.96336996 0.96703297 0.96703297 0.97069597 0.97069597 0.97435897
 0.97435897 0.98168498 0.98168498 0.98534799 0.98534799 0.98901099
 0.98901099 0.99267399 0.99267399 0.996337   0.996337   1.
 1.         1.         1.        ]
volGBM.auc:
0.9908930848157367
volMET.fpr:
[0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.003663   0.003663   0.00732601 0.00732601 0.01098901 0.01098901
 0.01465201 0.01465201 0.01831502 0.01831502 0.02564103 0.02564103
 0.02930403 0.02930403 0.03296703 0.03296703 0.03663004 0.03663004
 0.04029304 0.04029304 0.05494505 0.05494505 0.07326007 0.07326007
 0.08058608 0.08058608 0.08424908 0.08424908 0.1025641  0.1025641
 0.21611722 0.21611722 0.26007326 0.26007326 0.34432234 0.34432234
```

```
 1.        ]
volMET.tpr:
[0.         0.1878453  0.26519337 0.27071823 0.28729282 0.29281768
 0.31491713 0.32044199 0.34254144 0.37569061 0.38674033 0.40883978
 0.42541436 0.43093923 0.44198895 0.45303867 0.47513812 0.49171271
 0.50276243 0.51381215 0.52486188 0.58563536 0.59668508 0.84530387
 0.84530387 0.85635359 0.85635359 0.87292818 0.87292818 0.88950276
 0.88950276 0.90055249 0.90055249 0.90607735 0.90607735 0.91712707
 0.91712707 0.9281768  0.9281768  0.93370166 0.93370166 0.93922652
 0.93922652 0.95027624 0.95027624 0.9558011  0.9558011  0.96685083
 0.96685083 0.97237569 0.97237569 0.97790055 0.97790055 0.98342541
 0.98342541 0.98895028 0.98895028 0.99447514 0.99447514 1.
 1.        ]
volMET.auc:
0.9908323720478417

Metric auc:
------------------------------------------------
volGBM:
0.9908930848157367
volMET:
0.9908323720478417
macro_avg:
0.9908627284317892

Metric aucpr:
------------------------------------------------
volGBM:
0.9936129096208871
volMET:
0.9883560218639798
macro_avg:
0.9909844657424334

Metric brier-skill:
------------------------------------------------
0.8305695615278346
```

Brier-Skill Score L'**indice di Brier** indica la percentuale di incertezza del classificatore. E' un valore tra 0 e 1, e più vicino a zero è più è bassa l'incertezza del classificatore. La metrica che calcola Fuse è invece il complemento a 1 della percentuale dell'indice di brier, e quindi più è alto il **punteggio Brier-Skill**, minore sarà l'incertezza del classificatore.

Praticamente sto calcolando lo scarto quadratico medio delle predizioni.

1.11 Salvataggio in PDF

[ ]:
```
!wget -nc https://raw.githubusercontent.com/brpy/colab-pdf/master/colab_pdf.py
from colab_pdf import colab_pdf
colab_pdf('Elaborato_CCS.ipynb')
```

```
--2022-05-29 17:16:06--  https://raw.githubusercontent.com/brpy/colab-
pdf/master/colab_pdf.py
Resolving raw.githubusercontent.com (raw.githubusercontent.com)…
185.199.108.133, 185.199.109.133, 185.199.110.133, …
Connecting to raw.githubusercontent.com
(raw.githubusercontent.com)|185.199.108.133|:443… connected.
HTTP request sent, awaiting response… 200 OK
Length: 1864 (1.8K) [text/plain]
Saving to: ‘colab_pdf.py’

colab_pdf.py        100%[===================>]   1.82K  --.-KB/s    in 0s

2022-05-29 17:16:06 (37.9 MB/s) - ‘colab_pdf.py’ saved [1864/1864]


WARNING: apt does not have a stable CLI interface. Use with caution in scripts.


WARNING: apt does not have a stable CLI interface. Use with caution in scripts.

Extracting templates from packages: 100%
```