```
import os
import cv2
import random
import numpy as np
import pandas as pd
from tqdm import tqdm
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import random_split
from torch.utils.data import DataLoader, Dataset, Subset
from torch.utils.data import random_split, SubsetRandomSampler
from torchvision import datasets, transforms, models
from torchvision.datasets import ImageFolder
from torchvision.transforms import ToTensor
from torchvision.utils import make_grid
!pip install torch pytorch-lightning
from pytorch_lightning import LightningModule
from pytorch_lightning import Trainer
import pytorch_lightning as pl
import matplotlib.pyplot as plt
%matplotlib inline
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from PIL import Image
```

```
Requirement already satisfied: torch in /usr/local/lib/python3.10/dist-packages (2.0.1+cu118)
Collecting pytorch-lightning
  Downloading pytorch_lightning-2.0.6-py3-none-any.whl (722 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 722.8/722.8 kB 9.5 MB/s eta 0:00:00
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch) (3.12.2)
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from torch) (4.7.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch) (1.11.1)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch) (3.1)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch) (3.1.2)
Requirement already satisfied: triton==2.0.0 in /usr/local/lib/python3.10/dist-packages (from torch) (2.0.0)
Requirement already satisfied: cmake in /usr/local/lib/python3.10/dist-packages (from triton==2.0.0->torch) (3.25.2)
Requirement already satisfied: lit in /usr/local/lib/python3.10/dist-packages (from triton==2.0.0->torch) (16.0.6)
Requirement already satisfied: numpy>=1.17.2 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (1.22.4)
Requirement already satisfied: tqdm>=4.57.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (4.65.0)
Requirement already satisfied: PyYAML>=5.4 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (6.0.1)
Requirement already satisfied: fsspec[http]>2021.06.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (2023.6.0
Collecting torchmetrics>=0.7.0 (from pytorch-lightning)
  Downloading torchmetrics-1.0.1-py3-none-any.whl (729 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 729.2/729.2 kB 43.2 MB/s eta 0:00:00
Requirement already satisfied: packaging>=17.1 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (23.1)
Collecting lightning-utilities>=0.7.0 (from pytorch-lightning)
  Downloading lightning_utilities-0.9.0-py3-none-any.whl (23 kB)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from fsspec[http]>2021.06.0->pytorch-lightning)
Requirement already satisfied: aiohttp!=4.0.0a0,!=4.0.0a1 in /usr/local/lib/python3.10/dist-packages (from fsspec[http]>2021.06.0->
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->torch) (2.1.3)
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy->torch) (1.3.0)
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fsspec[ht
Requirement already satisfied: charset-normalizer<4.0,>=2.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fss
Requirement already satisfied: async-timeout<5.0,>=4.0.0a3 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.
Requirement already satisfied: yarl<2.0,>=1.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fsspec[h
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fsspe
Requirement already satisfied: aiosignal>=1.1.2 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fsspec
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->fsspec[http]>2021.0
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->fsspec[http]>2021.06.0
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->fsspec[http]>2021.06.0->pyto
Installing collected packages: lightning-utilities, torchmetrics, pytorch-lightning
Successfully installed lightning-utilities-0.9.0 pytorch-lightning-2.0.6 torchmetrics-1.0.1
```

```
transform=transforms.Compose([
        transforms.RandomRotation(10),      # rotate +/- 10 degrees
        transforms.RandomHorizontalFlip(),  # reverse 50% of images
        transforms.Resize(224),             # resize shortest side to 224 pixels
        transforms.CenterCrop(224),         # crop longest side to 224 pixels at center
        transforms.ToTensor(),
        transforms.Normalize([0.485, 0.456, 0.406],[0.229, 0.224, 0.225])
])
```

```
trainset=datasets.ImageFolder(root="/content/drive/MyDrive/Parkinsons/drawings/spiral/training",transform=None)
testset=datasets.ImageFolder(root="/content/drive/MyDrive/Parkinsons/drawings/spiral/testing",transform=None)

class_names=trainset.classes
print(class_names)
print(len(class_names))
```

```
['healthy', 'parkinson']
2
```

```
paths=[]
for dirname, _, filenames in os.walk('/content/drive/MyDrive/Parkinsons/drawings/spiral/training'):
    for filename in filenames:
        paths+=[(os.path.join(dirname, filename))]
```

```
class DataModule(pl.LightningDataModule):

    def __init__(self, transform=transform, batch_size=32):
        super().__init__()
        self.train_dir = "/content/drive/MyDrive/Parkinsons/drawings/spiral/training"
        self.test_dir = "/content/drive/MyDrive/Parkinsons/drawings/spiral/testing"
        self.transform = transform
        self.batch_size = batch_size

    def setup(self, stage=None):
        if stage == 'fit' or stage is None:
            self.trainset = datasets.ImageFolder(root=self.train_dir, transform=self.transform)
            self.train_dataloader_ = DataLoader(self.trainset, batch_size=self.batch_size, shuffle=True)

        if stage == 'test' or stage is None:
            self.testset = datasets.ImageFolder(root=self.test_dir, transform=self.transform)
            self.test_dataloader_ = DataLoader(self.testset, batch_size=self.batch_size)

    def train_dataloader(self):
        return self.train_dataloader_

    def test_dataloader(self):
        return self.test_dataloader_
```

```
class ConvolutionalNetwork(LightningModule):

    def __init__(self):
        super(ConvolutionalNetwork, self).__init__()
        self.conv1 = nn.Conv2d(3, 6, 3, 1)
        self.conv2 = nn.Conv2d(6, 16, 3, 1)
        self.fc1 = nn.Linear(16 * 54 * 54, 120)
        self.fc2 = nn.Linear(120, 84)
        self.fc3 = nn.Linear(84, 20)
        self.fc4 = nn.Linear(20, len(class_names))

    def forward(self, X):
        X = F.relu(self.conv1(X))
        X = F.max_pool2d(X, 2, 2)
        X = F.relu(self.conv2(X))
        X = F.max_pool2d(X, 2, 2)
        X = X.view(-1, 16 * 54 * 54)
        X = F.relu(self.fc1(X))
        X = F.relu(self.fc2(X))
        X = F.relu(self.fc3(X))
        X = self.fc4(X)
        return F.log_softmax(X, dim=1)

    def configure_optimizers(self):
        optimizer = torch.optim.Adam(self.parameters(), lr=0.001)
        return optimizer

    def training_step(self, train_batch, batch_idx):
        X, y = train_batch
        y_hat = self(X)
        loss = F.cross_entropy(y_hat, y)
        pred = y_hat.argmax(dim=1, keepdim=True)
        acc = pred.eq(y.view_as(pred)).sum().item() / y.shape[0]
        self.log("train_loss", loss)
        self.log("train_acc", acc)
        return loss

    def validation_step(self, val_batch, batch_idx):
        X, y = val_batch
        y_hat = self(X)
        loss = F.cross_entropy(y_hat, y)
        pred = y_hat.argmax(dim=1, keepdim=True)
        acc = pred.eq(y.view_as(pred)).sum().item() / y.shape[0]
        self.log("val_loss", loss)
        self.log("val_acc", acc)

    def test_step(self, test_batch, batch_idx):
        X, y = test_batch
        y_hat = self(X)
        loss = F.cross_entropy(y_hat, y)
        pred = y_hat.argmax(dim=1, keepdim=True)
        acc = pred.eq(y.view_as(pred)).sum().item() / y.shape[0]
        self.log("test_loss", loss)
        self.log("test_acc", acc)
```

```
datamodule = DataModule()
datamodule.setup()
train_loader = datamodule.train_dataloader()
for imgs,labels in train_loader:
    break
print(labels)
```

```
tensor([0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1,
        0, 0, 1, 1, 1, 0, 1, 1])
```

```
if __name__ == '__main__':
    datamodule = DataModule()
    datamodule.setup(stage='fit')
    model = ConvolutionalNetwork()
    trainer = pl.Trainer(max_epochs=600)
    trainer.fit(model, datamodule)
    datamodule.setup(stage='test')
    test_loader = datamodule.test_dataloader()
    trainer.test(dataloaders=test_loader)
```

```
INFO:pytorch_lightning.utilities.rank_zero:GPU available: False, used: False
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, using: 0 HPUs
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/configuration_validator.py:70: Possit
  rank_zero_warn(
WARNING:pytorch_lightning.loggers.tensorboard:Missing logger folder: /content/lightning_logs
INFO:pytorch_lightning.callbacks.model_summary:
  | Name  | Type   | Params
---------------------------------
0 | conv1 | Conv2d | 168
1 | conv2 | Conv2d | 880
2 | fc1   | Linear | 5.6 M
3 | fc2   | Linear | 10.2 K
4 | fc3   | Linear | 1.7 K
5 | fc4   | Linear | 42
---------------------------------
5.6 M     Trainable params
0         Non-trainable params
5.6 M     Total params
22.447    Total estimated model params size (MB)
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/loops/fit_loop.py:280: PossibleUserWarning: T
  rank_zero_warn(
Epoch 599: 100%                                        3/3 [00:01<00:00, 2.50it/s, v_num=0]
INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max_epochs=600` reached.
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/connectors/checkpoint_connector.py:14
  rank_zero_warn(
INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the checkpoint path at /content/lightr
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from the checkpoint at /content/lightni
Testing DataLoader 0: 100%                             1/1 [00:00<00:00, 5.83it/s]
```

Test metric	DataLoader 0
test_acc	0.6666666865348816
test_loss	4.018293857574463

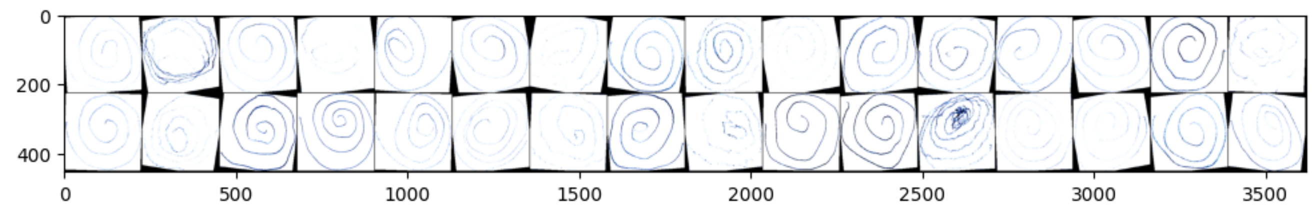
```
for images, labels in datamodule.train_dataloader():
    break
im=make_grid(images,nrow=16)

plt.figure(figsize=(12,12))
plt.imshow(np.transpose(im.numpy(),(1,2,0)))

inv_normalize=transforms.Normalize(mean=[-0.485/0.229,-0.456/0.224,-0.406/0.225],
                                   std=[1/0.229,1/0.224,1/0.225])
im=inv_normalize(im)

plt.figure(figsize=(12,12))
plt.imshow(np.transpose(im.numpy(),(1,2,0)))
```

```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integer
<matplotlib.image.AxesImage at 0x7c42e6a1c3d0>
```



```
device = torch.device("cpu")   #"cuda:0"

model.eval()
y_true=[]
y_pred=[]
with torch.no_grad():
    for test_data in datamodule.test_dataloader():
        test_images, test_labels = test_data[0].to(device), test_data[1].to(device)
        pred = model(test_images).argmax(dim=1)
        for i in range(len(pred)):
            y_true.append(test_labels[i].item())
            y_pred.append(pred[i].item())

print(classification_report(y_true,y_pred,target_names=class_names,digits=4))
```

```
              precision    recall  f1-score   support

     healthy     0.6250    0.6667    0.6452        15
   parkinson     0.6429    0.6000    0.6207        15

    accuracy                         0.6333        30
   macro avg     0.6339    0.6333    0.6329        30
weighted avg     0.6339    0.6333    0.6329        30
```