Detect Covid-19 with Chest X-Ray using PyTorch

Welcome to detecting Covid-19 with Chest X-ray using PyTorch!
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About this course

In 2 hour long guided project, we will use a ResNet-18 model and train it on a Covid-19 Radiography dataset. This dataset has nearly 3000 Chest X-ray scans wich are categorized in 3 classes:

- Normal
- Viral pneumonia
- Covid-19

Our objective in this project is to create an image classification model that can predict Chest X-ray scans that belong to one of 3 classes with a reasonably high accuracy. Please note that this dataset, and the model that we train in the project, can not be used to diagnose Covid-19 or viral pneumonia. We are only using this data for educational purpose.

Before you attempt this project, you should be familiar with:

- Programming python
- Theoretical understanding of CNN
- Understanding optimization techniques such as gradient descent
- This is a hands on, practical project that focuses primarily on implementation, and not on the theory of CNN.

Before diving into the project, please take a look at the course objectives and structure:

Course Objectives

In this course, we are going to focus on the following learning objectives:

1. Create custom dataset and dataloader in PyTorch
2. Train a ResNet-18 model in PyTorch to perform Image Classification

By the end of this course, you will be able to create a CNN, and will be able to train it to classify Chest X-Ray scans with reasonably high accuracy.

Course Structure

This course is divided into 3 parts:

1. Course overview: This introductory reading material

2. Detecting Covid-19 with Chest X-Ray using PyTorch: This is the hands on project that we will work on in Rhyme.
3. Graded Quiz: This is the final assignment that you need to pass in order to finish the course successfully.

Project Structure

The hands on project on detecting Covid-19 with Chest X-Ray using PyTorch is divided into following tasks:

1. Task 1: Introduction
2. Task 2: Importing libraries
3. Task 3: Creating custom dataset
4. Task 4: Image transformations
5. Task 5: Prepare DataLoader
6. Task 6: Data Visualization
7. Task 7: Creating the model
8. Task 8: Training the model
9. Task 9: Final results

Meet the instructor

Amit Yadav is a Machine Learning Engineer with focus in creating Deep Learning based Computer Vision and Signal Processing products. He has led chat bot development at a large corporation in the past. Amit is one of the Machine Learning and Data Science instructors at Rhyme.

Earn a Certificate

After you have completed the detecting Covid-19 with Chest X-Ray using PyTorch hands-on project, you will be able to assess your knowledge using an ungraded assignment.
Once you are comfortable with the concepts, take the final quiz, score higher than 80% to earn your certificate.

Learner Notebook

Task 1. Introduction

```
#add files of google colab
from google.colab import drive
drive.mount('/content/drive')
```

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

Task 2. Importing Libraries

```
#import libraries
%matplotlib inline
import os
import shutil
import random
import torch
import torchvision
import numpy as np
from PIL import Image
import matplotlib.pyplot as plt

#make seed to random
torch.manual_seed(0)

#print version of pytorch
print('Using PyTorch version ', torch.__version__)

```

```
Using PyTorch version  1.7.0+cu101
```

Preparing training and test sets

```
!ls '/content/drive/My Drive/Pytorch Scholarship Challenge/Detect Covid with x-ray/COVI
```

```
COVID-19                NORMAL.metadata.xlsx  'Viral Pneumonia.matadata.xlsx'
COVID-19.metadata.xlsx  README.md.txt
NORMAL                 'Viral Pneumonia'
```

```
#define classes
class_names = ['normal', 'viral', 'covid']
root_dir = '/content/drive/My Drive/Pytorch Scholarship Challenge/Detect Covid with x-r
source_dirs = ['NORMAL', 'Viral Pneumonia', 'COVID-19']

if os.path.isdir(os.path.join(root_dir, source_dirs[1])):
  os.mkdir(os.path.join(root_dir, 'test'))

  #define names of images of training set
  for i, d in enumerate(source_dirs):
    os.rename(os.path.join(root_dir, d), os.path.join(root_dir, class_names[i]))

  for c in class_names:
    os.mkdir(os.path.join(root_dir, 'test', c))

  #define 30 samples of images of test set
  for c in class_names:
    images = [x for x in os.listdir(os.path.join(root_dir, c)) if x.lower().endswith('p
    selected_images = random.sample(images, 30)
```

```
    selected_images = random.sample(images, 30)

    for image in selected_images:
      source_path = os.path.join(root_dir, c, image)
      target_path = os.path.join(root_dir, 'test', c, image)
      shutil.move(source_path, target_path)
```

```
!ls '/content/drive/My Drive/Pytorch Scholarship Challenge/Detect Covid with x-ray/COVI
```

```
covid                    NORMAL.metadata.xlsx   viral
COVID-19.metadata.xlsx   README.md.txt         'Viral Pneumonia.matadata.xlsx'
normal                   test
```

Task 3. Creating custom dataset

```
class ChestXRayDataset(torch.utils.data.Dataset):
  def __init__(self, image_dirs, transform):
    def get_images(class_name):
      images = [x for x in os.listdir(image_dirs[class_name]) if x.lower().endswith('pr
      print(f'Found {len(images)} {class_name} examples')
      return images

    self.images = {}
    self.class_names = ['normal', 'viral', 'covid']

    for c in self.class_names:
      self.images[c] = get_images(c)

    self.image_dirs = image_dirs
    self.transform = transform

  def __len__(self):
    return sum([len(self.images[c]) for c in self.class_names])

  def __getitem__(self, index):
    class_name = random.choice(self.class_names)
    index = index % len(self.images[class_name])
    image_name = self.images[class_name][index]
    image_path = os.path.join(self.image_dirs[class_name], image_name)
    image = Image.open(image_path).convert('RGB')
    return self.transform(image), self.class_names.index(class_name)
```

Task 4. Image transformation

```
#transformation to train set
train_transform = torchvision.transforms.Compose([
    torchvision.transforms.Resize(size = (224, 224)),
    torchvision.transforms.RandomHorizontalFlip(),
    torchvision.transforms.ToTensor(),
```

```
    torchvision.transforms.Normalize(mean = [0.485, 0.456, 0.406],
                                     std = [0.229, 0.224, 0.225])
])

#transformation to test set
test_transform = torchvision.transforms.Compose([
    torchvision.transforms.Resize(size = (224, 224)),
    torchvision.transforms.ToTensor(),
    torchvision.transforms.Normalize(mean = [0.485, 0.456, 0.406],
                                     std = [0.229, 0.224, 0.225])
])
```

Task 5. Prepare DataLoader

```
path_dir = '/content/drive/My Drive/Pytorch Scholarship Challenge/Detect Covid with x-r
```

```
train_dirs = {
    'normal' : path_dir + 'COVID-19 Radiography Database/normal',
    'viral' : path_dir + 'COVID-19 Radiography Database/viral',
    'covid' : path_dir + 'COVID-19 Radiography Database/covid'
}

train_dataset = ChestXRayDataset(train_dirs, train_transform)
```

```
Found 1311 normal examples
Found 1315 viral examples
Found 189 covid examples
```

```
test_dirs = {
    'normal' : path_dir + 'COVID-19 Radiography Database/test/normal',
    'viral' : path_dir + 'COVID-19 Radiography Database/test/viral',
    'covid' : path_dir + 'COVID-19 Radiography Database/test/covid'
}

test_dataset = ChestXRayDataset(test_dirs, test_transform)
```

```
Found 30 normal examples
Found 30 viral examples
Found 30 covid examples
```

```
#results of data loader
batch_size = 6

#dataloader of train
dl_train = torch.utils.data.DataLoader(train_dataset,
                                       batch_size = batch_size,
                                       shuffle = True)
#dataloader of test
dl_test = torch.utils.data.DataLoader(test_dataset,
                                      batch_size = batch_size,
                                      shuffle = True)
#print results
```

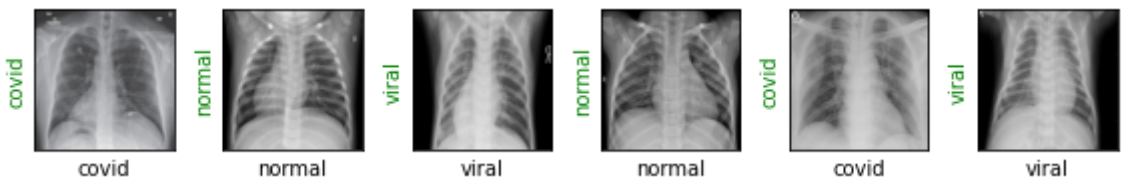
```
#print results
print(f'Num of training batches: {len(dl_train)}')
print(f'Num of testing batches: {len(dl_test)}')

```

```
Num of training batches: 470
Num of testing batches: 15
```

Task 6. Data Visualization

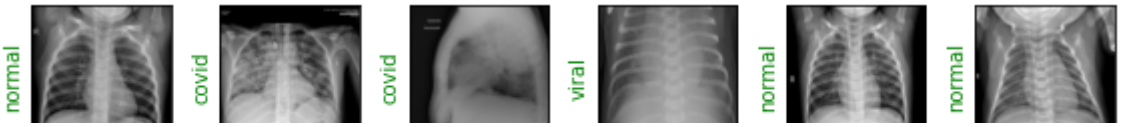
```
class_names = train_dataset.class_names

def show_images(images, labels, preds):
  plt.figure(figsize = (8, 4))

  for i, image in enumerate(images):
    plt.subplot(1, 6, i+1, xticks = [], yticks = [])
    image = image.numpy().transpose((1, 2, 0))
    mean = np.array([0.485, 0.456, 0.406])
    std = np.array([0.229, 0.224, 0.225])
    image = image * std + mean
    image = np.clip(image, 0., 1.)
    plt.imshow(image)

    col = 'green' if preds[i] == labels[i] else 'red'
    plt.xlabel(f'{class_names[int(labels[i].numpy())]}')
    plt.ylabel(f'{class_names[int(preds[i].numpy())]}', color = col)

  plt.tight_layout()
  plt.show()

```

```
#show images of training
images, labels = next(iter(dl_train))
show_images(images, labels, labels)
print(images.shape)
```




```
torch.Size([6, 3, 224, 224])
```

```
#show images of testing
images, labels = next(iter(dl_test))
show_images(images, labels, labels)
print(images.shape)
```



Task 7. Creating the Model

```
#load pre-trained resnet-18 model
resnet18 = torchvision.models.resnet18(pretrained = True)
print(resnet18)
```

```
Downloading: "https://download.pytorch.org/models/resnet18-5c106cde.pth" to /root/.c
100%                                  44.7M/44.7M [00:01<00:00, 24.3MB/s]
```

```
ResNet(
  (conv1): Conv2d(3, 64, kernel_size=(7, 7), stride=(2, 2), padding=(3, 3), bias=Fal
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=T
  (relu): ReLU(inplace=True)
  (maxpool): MaxPool2d(kernel_size=3, stride=2, padding=1, dilation=1, ceil_mode=Fal
  (layer1): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bia
      (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_sta
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bia
      (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_sta
    )
    (1): BasicBlock(
      (conv1): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bia
      (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_sta
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bia
      (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_sta
    )
  )
  (layer2): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(64, 128, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bi
      (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_st
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
      (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_st
      (downsample): Sequential(
        (0): Conv2d(64, 128, kernel_size=(1, 1), stride=(2, 2), bias=False)
        (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_st
      )
    )
    (1): BasicBlock(
      (conv1): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
      (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_st
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
```

```
#editing fully-connected layer
resnet18.fc = torch.nn.Linear(in_features = 512, out_features = 3)
loss_fn = torch.nn.CrossEntropyLoss()
optimizer = torch.optim.Adam(resnet18.parameters(), lr = 3e-5)
```

```
      (conv1): Conv2d(128, 256, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), b
```

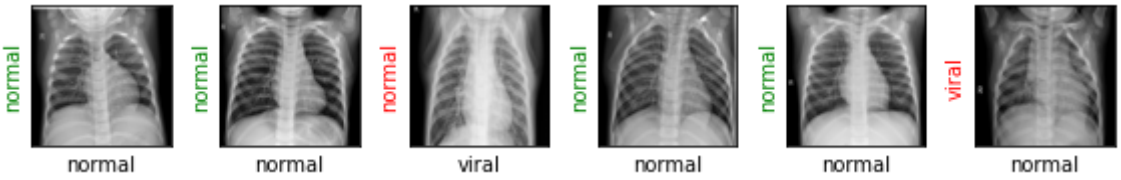
```
#print editted model
print(resnet18)
```

```
      (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_
      (downsample): Sequential(
        (0): Conv2d(64, 128, kernel_size=(1, 1), stride=(2, 2), bias=False)
        (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_
      )
    )
    (1): BasicBlock(
```

```
      (conv1): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_
    )
  )
  (layer3): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(128, 256, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1),
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_
      (downsample): Sequential(
        (0): Conv2d(128, 256, kernel_size=(1, 1), stride=(2, 2), bias=False)
        (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_
      )
    )
    (1): BasicBlock(
      (conv1): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_
    )
  )
  (layer4): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(256, 512, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1),
      (bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_
      (downsample): Sequential(
        (0): Conv2d(256, 512, kernel_size=(1, 1), stride=(2, 2), bias=False)
        (1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_
      )
    )
    (1): BasicBlock(
      (conv1): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
      (bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_
    )
  )
  (avgpool): AdaptiveAvgPool2d(output_size=(1, 1))
  (fc): Linear(in features=512, out features=3, bias=True)
```

```
#define function to show predictions

def show_preds():
  resnet18.eval()
  images, labels = next(iter(dl_test))
  outputs = resnet18(images)
  _, preds = torch.max(outputs, 1)
  show_images(images, labels, preds)

```

```
1 show_preds()
```



Task 8. Training the model

```
1 def training(epochs):
2   print('Starting training....')
3 
4   for e in range(0, epochs):
5     print('=' * 20)
6     print(f'Starting epoch {e+1}/{epochs}')
7     print('=' * 20)
8 
9     train_loss = 0.
10    resnet18.train()
11 
12    for train_step, (images, labels) in enumerate(dl_train):
13      optimizer.zero_grad()
14      outputs = resnet18(images)
15      loss = loss_fn(outputs, labels)
16      loss.backward()
17      optimizer.step()
18      train_loss += loss.item()
19 
20      if train_step % 20 == 0:
21        print('Evaluating step...', train_step)
22        val_loss = 0.
23        accuracy = 0.
24        resnet18.eval()
25 
26        for val_step, (images, labels) in enumerate(dl_test):
27          outputs = resnet18(images)
28          loss = loss_fn(outputs, labels)
29          val_loss += loss.item()
30          _, preds = torch.max(outputs, 1)
31          accuracy += sum((preds == labels).numpy())
32        val_loss /= (val_step+1)
33        accuracy = accuracy/len(test_dataset)
34        print(f'Val loss: {val_loss:.4f}  ===> Accuracy: {accuracy:.3f}')
35        show_preds()
36 
37        resnet18.train()
38 
39        if accuracy > 0.95:
40          print('Performance condition satisfied...')
41          return
```

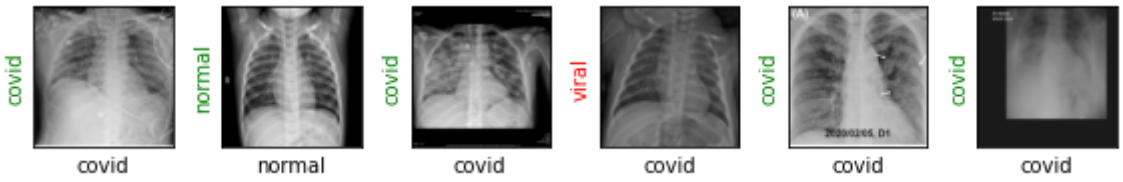
```
42
43     train_loss /= (train_step + 1)
44     print(f'Training loss: {train_loss:.4f}')
45
```

```
1 training(epochs = 1)
```

```
Starting training....
====================
Starting epoch 1/1
====================
Evaluating step... 0
Val loss: 0.8886  ===> Accuracy: 0.544
```

Task 9. Final Results

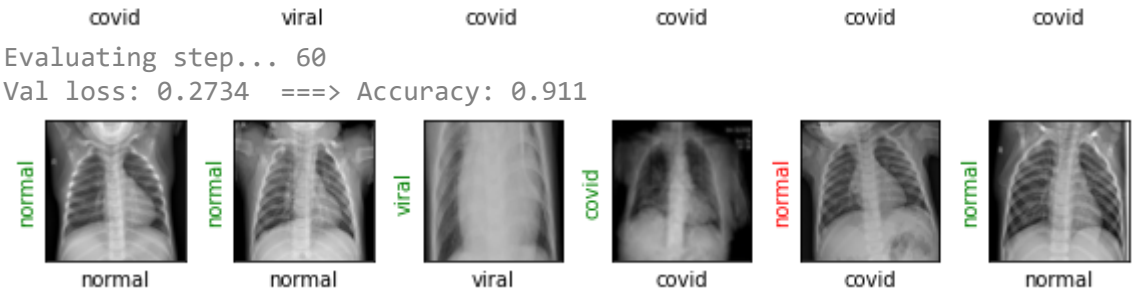
```
1 show_preds()
```




```
Evaluating step... 40
```

Project Finalized ... Congrats Holger Espinola ! ..... Enjoy Coursera!

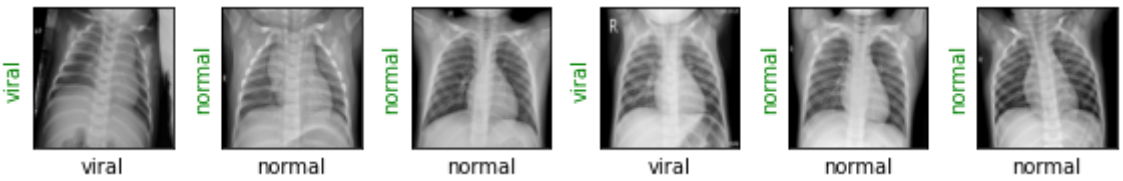
```
1
```




```
Evaluating step... 60
Val loss: 0.2734  ===> Accuracy: 0.911
```



```
Evaluating step... 80
Val loss: 0.2073  ===> Accuracy: 0.922
```




```
Evaluating step... 100
Val loss: 0.1806  ===> Accuracy: 0.933
```