Learner Notebook

July 7, 2025

1 Importing Libraries

[7]:

```python
%matplotlib inline

import os
import shutil
import random
import torch
import torchvision
import numpy as np

from PIL import Image
from matplotlib import pyplot as plt

torch.manual_seed(0)

print('Using PyTorch version', torch.__version__)
```

```
Using PyTorch version 2.3.1+cu121
```

2 Preparing Training and Test Sets

[8]:

```python
class_names = ['normal', 'viral', 'covid']
root_dir = 'COVID-19 Radiography Database'
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'))

    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))

    for c in class_names:
        images = [x for x in os.listdir(os.path.join(root_dir, c)) if x.lower().
 ↪endswith('png')]
        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)
```

3 Creating Custom Dataset

[9]:

```
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('png')]
            print(f'Found {len(images)}{class_name}')
            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)
```

4 Image Transformations

[10]:

```
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])
])
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])
])
```

5 Prepare DataLoader

[11]:
```
train_dirs = {
    'normal': 'COVID-19 Radiography Database/normal',
    'viral': 'COVID-19 Radiography Database/viral',
    'covid': 'COVID-19 Radiography Database/covid'
}
train_dataset=ChestXRayDataset(train_dirs, train_transform)
```

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

[12]:
```
test_dirs = {
    'normal': 'COVID-19 Radiography Database/test/normal',
    'viral': 'COVID-19 Radiography Database/test/viral',
    'covid': 'COVID-19 Radiography Database/test/covid'
}
test_dataset = ChestXRayDataset(test_dirs, test_transform)
```

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

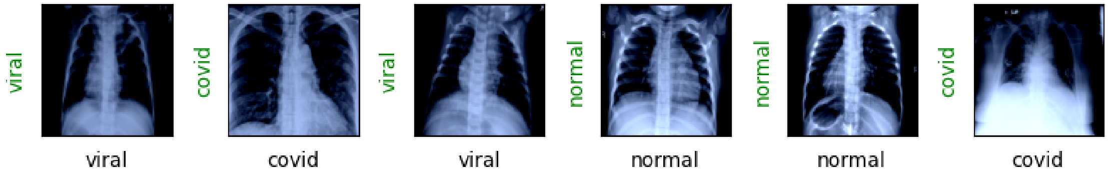
[13]:
```
batch_size=6
dl_train = torch.utils.data.DataLoader(train_dataset, batch_size=batch_size,␣
 ↪shuffle=True)
dl_test = torch.utils.data.DataLoader(test_dataset, batch_size=batch_size,␣
 ↪shuffle=True)
print('Num of training batches', len(dl_train))
print('Num of test batches', len(dl_test))
```

```
Num of training batches 470
Num of test batches 15
```

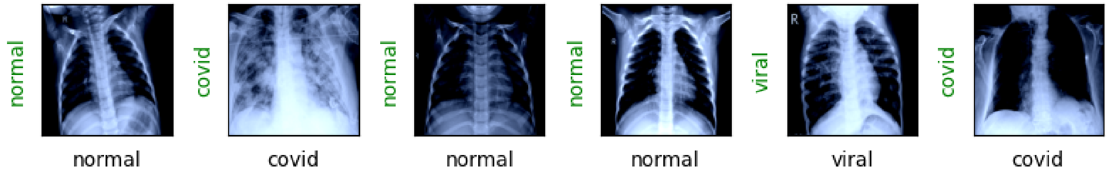
6 Data Visualization

[14]:
```
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()
```

[15]:
```
images, labels =next(iter(dl_train))
show_images(images, labels, labels)
```



[16]:
```
images, labels =next(iter(dl_test))
show_images(images, labels, labels)
```



7 Creating the Model

[17]:
```
resnet18 =torchvision.models.resnet18(pretrained=True)
print(resnet18)
```

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

```
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (layer3): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(128, 256, kernel_size=(3, 3), stride=(2, 2), padding=(1,
1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (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_stats=True)
      )
    )
    (1): BasicBlock(
      (conv1): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (layer4): Sequential(
    (0): BasicBlock(
      (conv1): Conv2d(256, 512, kernel_size=(3, 3), stride=(2, 2), padding=(1,
1), bias=False)
      (bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (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_stats=True)
      )
    )
    (1): BasicBlock(
      (conv1): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (relu): ReLU(inplace=True)
      (conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (avgpool): AdaptiveAvgPool2d(output_size=(1, 1))
  (fc): Linear(in_features=512, out_features=1000, bias=True)
)
```

[18]:

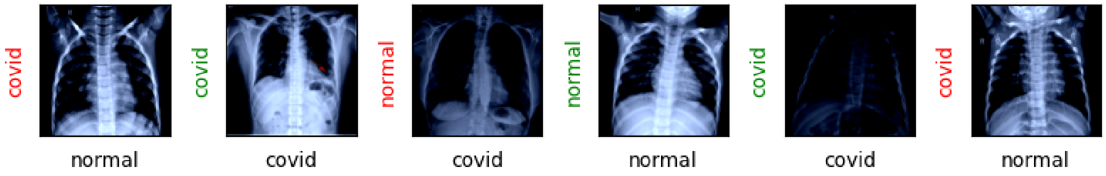
```
resnet18.fc=torch.nn.Linear(in_features=512, out_features=3)
loss_fn=torch.nn.CrossEntropyLoss()
optimizer=torch.optim.Adam(resnet18.parameters(), lr=3e-5)
```

[19]:

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

[20]:

```
show_preds()
```



8 Training the Model

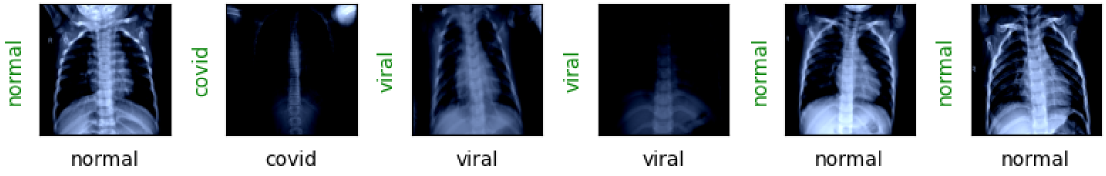
[27]:

```
def train(epochs):
    print('Starting training..')
    for e in range(0, epochs):
        print(f'Starting epoch {e+1}/{epochs}')
        print('='*20)
        train_loss=0
        resnet18.train()
        for train_step, (images, labels) in enumerate(dl_train):
            optimizer.zero_grad()
            outputs=resnet18(images)
            loss=loss_fn(outputs, labels)
            loss.backward()
            optimizer.step()
            train_loss=loss.item()
            if train_step%20==0:
                print('Evaluating at step', train_step)
                acc=0.
                val_loss=0.
                resnet18.eval()
                for val_step,(images, labels) in enumerate(dl_test):
                    outputs=resnet18(images)
                    loss=loss_fn(outputs, labels)
                    val_loss+=loss.item()
                    _,preds=torch.max(outputs, 1)
                    acc+=sum(preds==labels).numpy()
                val_loss/=(val_step+1)
                acc=acc/len(test_dataset)
                print(f'Val loss: {val_loss:.4f}, Acc: {acc:.4f}')
                show_preds()
                resnet18.train()
                if acc >0.95:
                    print('Performance condition satisfied..')
                    return
        train_loss/=(train_step+1)
        print(f'Training loss: {train_loss:.4f}')
```

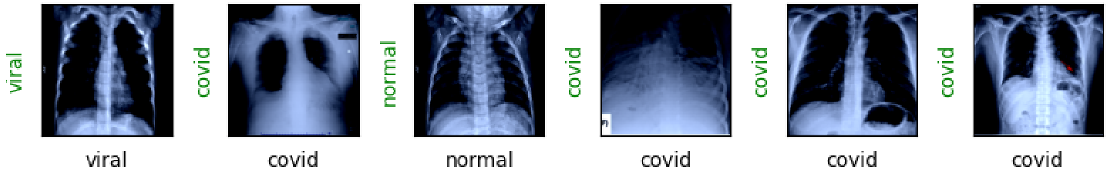
[28]:

```
train(epochs=1)
```

```
Starting training..
Starting epoch 1/1
====================
Evaluating at step 0
Val loss: 0.2160, Acc: 0.9444
```



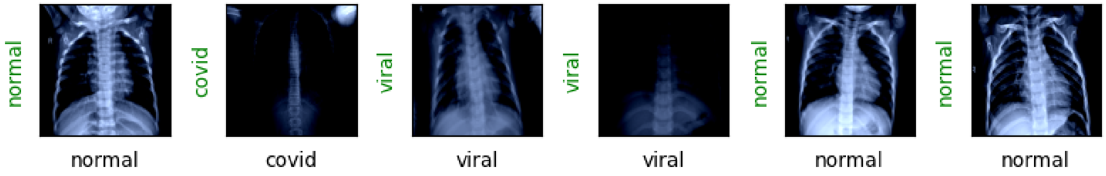
```
Evaluating at step 20
Val loss: 0.1231, Acc: 0.9556
```



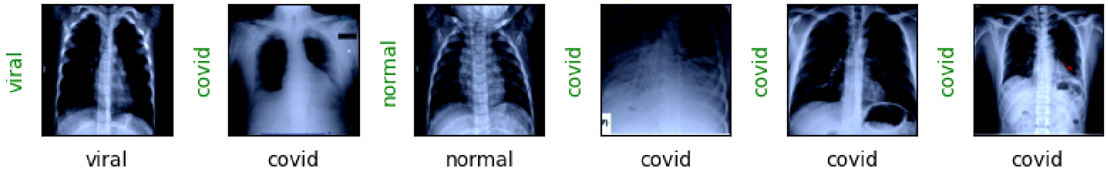
```
Performance condition satisfied..
```

```
[28]: train(epochs=1)
```

```
Starting training..
Starting epoch 1/1
====================
Evaluating at step 0
Val loss: 0.2160, Acc: 0.9444
```



```
Evaluating at step 20
Val loss: 0.1231, Acc: 0.9556
```



```
Performance condition satisfied..
```

9 Final Results

[26]:
```
show_preds()
```