```
#import libraries

import os
import torch
import torch.nn as nn
import numpy as np
#import libraries

import os
import torch
import torch.nn as nn
import numpy as np
import matplotlib.pyplot as plt
import torchvision
import torch.nn.functional as F
from torchvision.transforms import ToTensor
from torch.utils.data import DataLoader
from torchvision.datasets import ImageFolder
import torchvision.transforms as T
%matplotlib inline
from torchvision.datasets import ImageFolder
import torchvision.transforms as T
%matplotlib inline
```

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

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
import os
directory_path = "/content/drive/MyDrive/Cotton Disease"
print(os.listdir(directory_path))

```

```
['test', 'train', 'val']
```

```
print(os.listdir(directory_path))
classes = os.listdir(directory_path + "/train")
print(classes)
```

```
['test', 'train', 'val']
['fresh cotton leaf', 'fresh cotton plant', 'diseased cotton plant', 'diseased cotton leaf']
```

```
diseased_cotton_leaf = os.listdir(directory_path + "/train/diseased cotton leaf")
print(diseased_cotton_leaf[:10])
```

```
['dis_leaf (111)_iaip.jpg', 'dis_leaf (120)_iaip.jpg', 'dis_leaf (110)_iaip.jpg', 'dis_leaf (121)_iaip.jpg', 'dis_leaf (126)_iaip.jpg',
```

```
for i in classes:
  result = os.listdir(directory_path + "/train/" + i)
  print(f"Number of Images in {i} = {len(result)}")
```

```
Number of Images in fresh cotton leaf = 427
Number of Images in fresh cotton plant = 421
Number of Images in diseased cotton plant = 815
Number of Images in diseased cotton leaf = 288
```

```
image_size = 32
batch_size = 200
stats = ((0.4914, 0.4822, 0.4465), (0.2023, 0.1994, 0.2010))
```

```
train_ds = ImageFolder(directory_path + "/train", transform=T.Compose ([
    T.Resize((image_size, image_size)),
    T.CenterCrop((image_size, image_size)),
    T.ToTensor(), T.Normalize(*stats)
]))

val_ds = ImageFolder(directory_path + "/val", transform=T.Compose([
    T.Resize((image_size, image_size)),
```

```
    T.CenterCrop((image_size, image_size)),
    T.ToTensor(), T.Normalize(*stats)
]))
```

```
train_dl = DataLoader(train_ds, batch_size, shuffle=True, num_workers=3, pin_memory=True)
val_dl = DataLoader(val_ds, batch_size*2, num_workers=4, pin_memory=True)
```

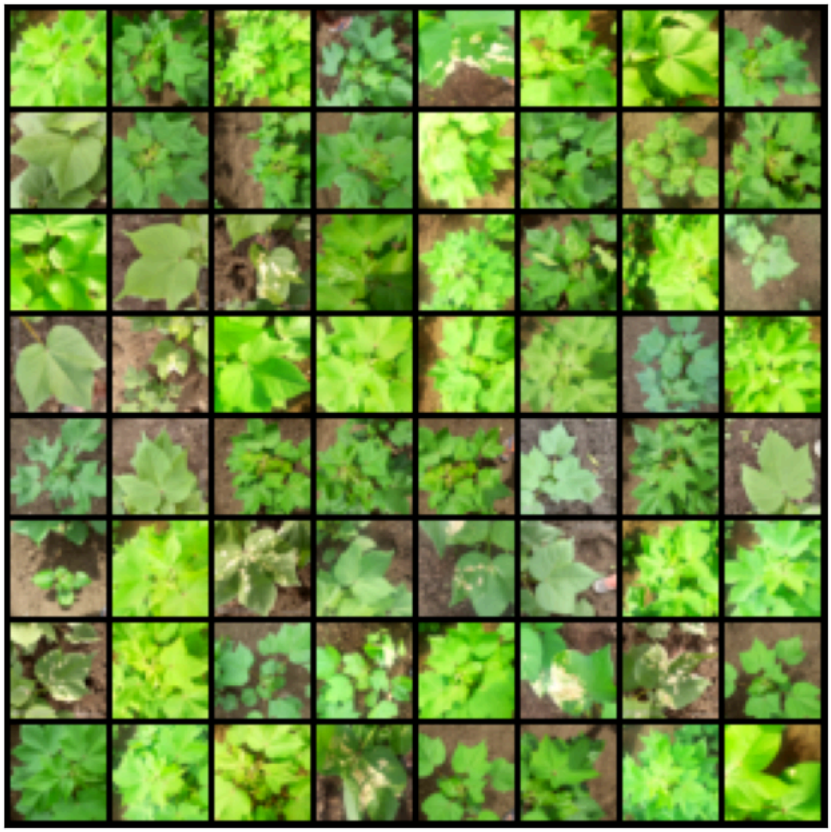
```
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:617: UserWarning: This DataLoader will create 3 worker processes
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:617: UserWarning: This DataLoader will create 4 worker processes
  warnings.warn(
```

```
def denorm(img_tensors):
  return img_tensors * stats[1][10] + stats[0][0]
```

```
from torchvision.utils import make_grid
```

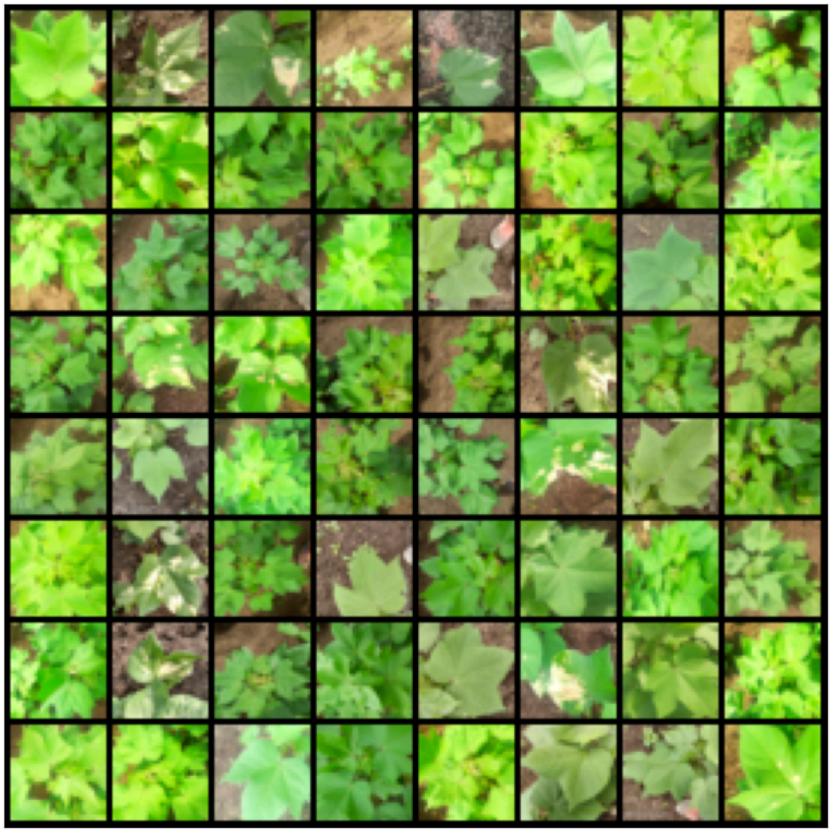
```
# Define the normalization parameters
means = [0.485, 0.456, 0.406]
stds = [0.229, 0.224, 0.225]

# Function to denormalize images
def denormalize(images, means, stds):
    means = torch.tensor(means).view(1, 3, 1, 1)
    stds = torch.tensor(stds).view(1, 3, 1, 1)
    return images * stds + means

# Function to show images
def show_images(images, means, stds, nmax=64):
    images = denormalize(images, means, stds)
    fig, ax = plt.subplots(figsize=(8, 8))
    ax.set_xticks([]); ax.set_yticks([])
    ax.imshow(make_grid(images[:nmax], nrow=8).permute(1, 2, 0))

# Function to show a batch
def show_batchs(dl, means, stds, nmax=64):
    for images, _ in dl:
        show_images(images, means, stds, nmax)
        break

# Call the function
show_batchs(train_dl, means, stds, nmax=64)
```

```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). G
```



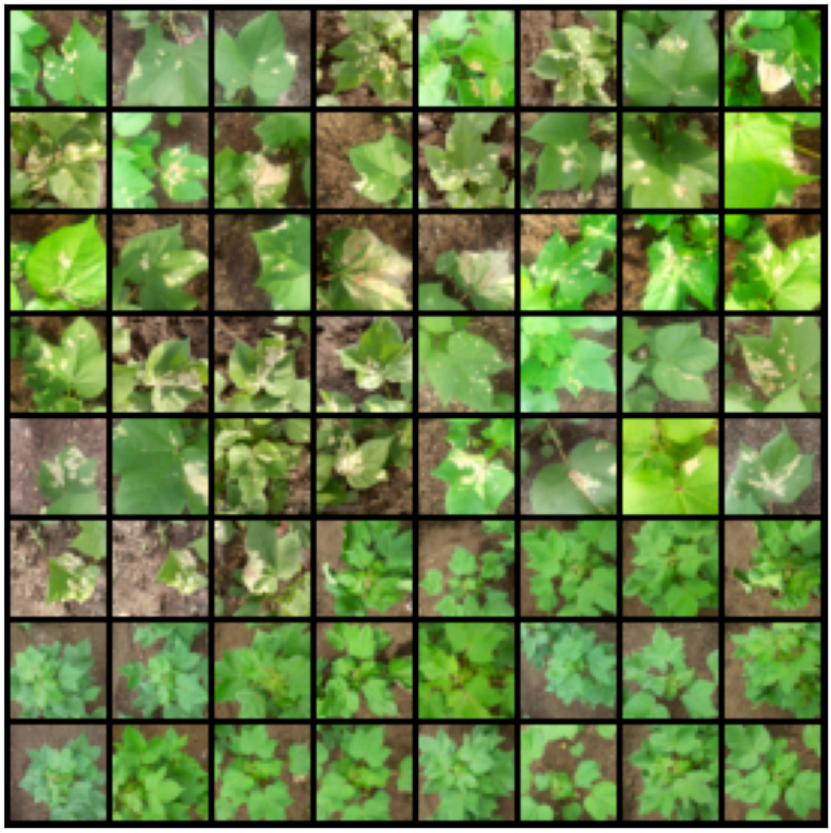
```
show_batchs(train_dl, means, stds)
torch.cuda.empty_cache()
```

```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). G
```



```
show_batchs(val_dl, means, stds)
```

```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). G
```



```
class ImageClassificationBase(nn.Module):
  def training_step(self, batch):
    images, labels = batch
    out = self(images)
    loss = F.cross_entropy(out, labels)
    return loss

  def validation_step(self, batch):
    images, labels = batch
    out = self(images)
    loss = F.cross_entropy(out, labels)
    acc = self.accuracy(out, labels)
    return {'val_loss': loss.detach(), 'val_acc': acc}

  def validation_epoch_end(self, outputs):
    batch_losses = [x['val_loss'] for x in outputs]
    epoch_loss = torch.stack(batch_losses).mean()
    batch_accs = [x['val_acc'] for x in outputs]
    epoch_acc = torch.stack(batch_accs).mean()
    return {'val_loss': epoch_loss.item(),'val_acc':epoch_acc.item()}

  def epoch_end(self, epoch, result):
    print("Epoch [{}],train_loss: {:.4f},val_loss: {:.4f}, val_acc: {:.4f}".format(
        epoch, result['train_loss'], result['val_loss'], result['val_acc']
    ))
def accuracy(self, outputs, labels):
  _, preds = torch.max(outputs, dim=1)
  return torch.tensor(torch.sum(preds == labels).item() / len(preds))
```

```
class CnnModel(ImageClassificationBase):
  def __init__(self):
    super().__init__()
    self.network = nn.Sequential(
        nn.Conv2d(3, 32, kernel_size=3, padding=1),
        nn.ReLU(),
```

```
        nn.Conv2d(32, 64, kernel_size=3, stride=1, padding=1),
        nn.ReLU(),
        nn.MaxPool2d(2,2),

        nn.Conv2d(64, 128, kernel_size=3, stride=1, padding=1),
        nn.ReLU(),
        nn.Conv2d(128, 128, kernel_size=3, stride=1, padding=1),
        nn.ReLU(),
        nn.MaxPool2d(2,2),

        nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1),
        nn.ReLU(),
        nn.Conv2d(256, 256, kernel_size=3, stride=1, padding=1),
        nn.ReLU(),
        nn.MaxPool2d(2,2),

        nn.Flatten(),
        nn.Linear(256*4*4, 512),
        nn.ReLU(),
        nn.Linear(512, 512),
        nn.ReLU(),
        nn.Linear(512,4)
    )

  def forward(self, xb):
    return self.network(xb)

  def accuracy(self, outputs, labels):
    _, preds = torch.max(outputs, dim=1)
    return torch.tensor(torch.sum(preds == labels).item() / len(preds))
```

```
model = CnnModel()
model
```

```
CnnModel(
  (network): Sequential(
    (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU()
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU()
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): ReLU()
    (12): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (13): ReLU()
    (14): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (15): Flatten(start_dim=1, end_dim=-1)
    (16): Linear(in_features=4096, out_features=512, bias=True)
    (17): ReLU()
    (18): Linear(in_features=512, out_features=512, bias=True)
    (19): ReLU()
    (20): Linear(in_features=512, out_features=4, bias=True)
  )
)
```

```

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model = model.to(device)

for images, labels in train_dl:
  print('images.shape:', images.shape)


  images = images.to(device)

  out = model(images)
  print('out.shape:', out.shape)
  print('out[0]:', out[0])
  break
```

```
  break

```

```
images.shape: torch.Size([200, 3, 32, 32])
out.shape: torch.Size([200, 4])
out[0]: tensor([ 0.0419, -0.0421, -0.0315, -0.0203], grad_fn=<SelectBackward0>)
```

```
def get_default_device():
  if torch.cuda.is_available():
    return torch.device('cuda')
  else:
    return torch.device('cpu')

def to_device(data, device):
  if isinstance(data, (list, tuple)):
    return [to_device(x, device) for x in data]
  return data.to(device, non_blocking=True)

class DeviceDataLoader():
  def __init__(self, dl, device):
    self.dl = dl
    self.device = device

  def __iter__(self):
    for b in self.dl:
      yield to_device(b, self.device)

  def __len__(self):
    return len(self.dl)
```

```
device = get_default_device()
device
```

```
device(type='cpu')
```

```
train_dl = DeviceDataLoader(train_dl, device)
val_dl = DeviceDataLoader(val_dl, device)
to_device(model,device);
```

```
@torch.no_grad()
def evaluate(model, val_loader):
  model.eval()
  outputs = [model.validation_step(batch) for batch in val_loader]
  return model.validation_epoch_end(outputs)

def fit(epochs, lr, model, train_loader, val_loader, opt_func=torch.optim.SGD):
  history = []
  optimizer = opt_func(model.parameters(),lr)
  for epoch in range(epochs):
    model.train()
    train_losses = []
    for batch in train_loader:
      loss = model.training_step(batch)
      train_losses.append(loss)
      loss.backward()
      optimizer.step()
      optimizer.zero_grad()
    result = evaluate(model, val_loader)
    result['train_loss'] = torch.stack(train_losses).mean().item()
    model.epoch_end(epoch, result)
    history.append(result)
  return history


```

```
model = to_device(CnnModel(), device)

```

```
evaluate(model, val_dl)
```

```
{'val_loss': 1.3903604745864868, 'val_acc': 0.16996046900749207}
```

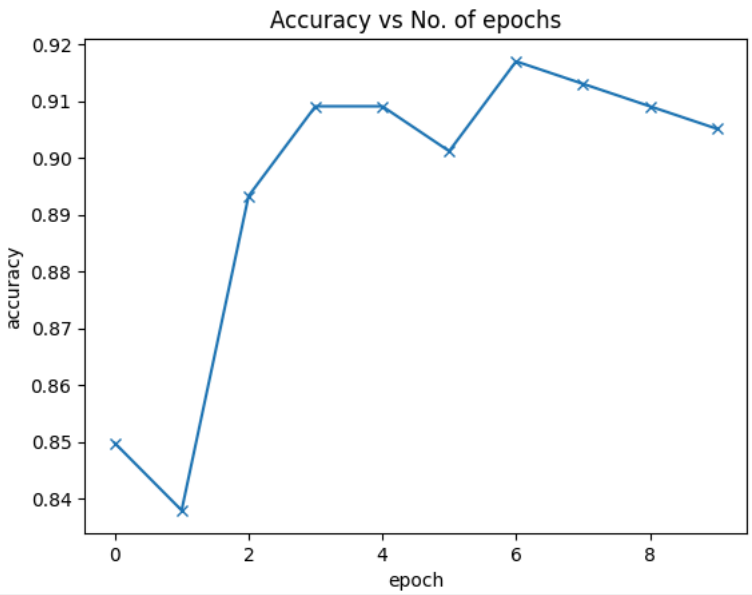
```
num_epochs = 10
opt_func = torch.optim.Adam
lr = 0.001
```

```
%%time
history = fit(num_epochs, lr, model, train_dl, val_dl, opt_func)
```

```
Epoch [0],train_loss: 0.7017,val_loss: 0.5209, val_acc: 0.8498
Epoch [1],train_loss: 0.3877,val_loss: 0.4412, val_acc: 0.8379
Epoch [2],train_loss: 0.2776,val_loss: 0.2858, val_acc: 0.8933
Epoch [3],train_loss: 0.2045,val_loss: 0.2652, val_acc: 0.9091
Epoch [4],train_loss: 0.1536,val_loss: 0.3391, val_acc: 0.9091
Epoch [5],train_loss: 0.1384,val_loss: 0.2437, val_acc: 0.9012
Epoch [6],train_loss: 0.1204,val_loss: 0.2134, val_acc: 0.9170
Epoch [7],train_loss: 0.1102,val_loss: 0.2615, val_acc: 0.9130
Epoch [8],train_loss: 0.0823,val_loss: 0.3252, val_acc: 0.9091
Epoch [9],train_loss: 0.0561,val_loss: 0.2519, val_acc: 0.9051
CPU times: user 5min 57s, sys: 20.9 s, total: 6min 18s
Wall time: 8min 35s
```

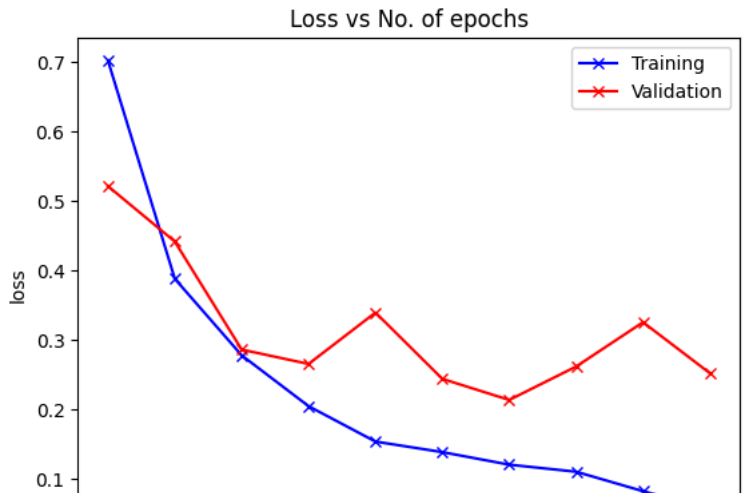
```
def plot_accuracies(history):
  accuracies = [x['val_acc'] for x in history]
  plt.plot(accuracies, '-x')
  plt.xlabel('epoch')
  plt.ylabel('accuracy')
  plt.title('Accuracy vs No. of epochs')
```

```
plot_accuracies(history)
```




```
def plot_losses(history):
  train_losses = [x.get('train_loss') for x in history]
  val_losses = [x ['val_loss'] for x in history]
  plt.plot(train_losses, '-bx')
  plt.plot(val_losses, '-rx')
  plt.xlabel('epoch')
  plt.ylabel('loss')
  plt.legend(['Training', 'Validation'])
  plt.title('Loss vs No. of epochs')
```

```
plot_losses(history)
```




```
test_dataset =  ImageFolder(directory_path + "/test", transform=T.Compose([
    T.Resize((image_size, image_size)),
    T.CenterCrop((image_size, image_size)),
    T.ToTensor(), T.Normalize(*stats)
]))
```

```
def predict_image(img, model):
  xb = to_device(img.unsqueeze(0), device)
  yb = model(xb)
  _, preds = torch.max(yb, dim=1)
  return train_ds.classes[preds[0].item()]
```

```
dataset = ImageFolder(directory_path + "/train", transform=ToTensor())
```

```
torch.save(model.state_dict(), 'cotton_disease_model.pth')
```

```
def denorm(img_tensors):
    # Unnormalize the image tensor using mean and std for each channel
    mean = torch.tensor(stats[0])  # mean = [mean_r, mean_g, mean_b]
    std = torch.tensor(stats[1])   # std = [std_r, std_g, std_b]
    return img_tensors * std + mean

```

```
test_dataset1 =  ImageFolder(directory_path + "/test", transform=ToTensor())
img, label = test_dataset[0]
plt.imshow(denorm(img.permute(1,2,0)))
print('label:', dataset.classes[label], ',Predicted:', predict_image(img, model))
```

```
label: diseased cotton leaf ,Predicted: diseased cotton leaf
```