Train a VGG on MNIST dataset

[2]:
```
import torch
import torch.nn as nn
import torch.optim as optim
import torchvision.transforms as transforms
import torchvision.datasets as datasets
import matplotlib.pyplot as plt
from torch.utils.data import DataLoader
from tqdm import tqdm
```

[5]:
```
device_name = "cuda" if torch.cuda.is_available() else "cpu"
device = torch.device(device_name)
print(f"Device:{device_name}")
```

```
Device:cuda
```

[17]:
```
class SmallVGG(nn.Module):
    def __init__(self):
        super(SmallVGG, self).__init__()
        self.conv_layers = nn.Sequential(
            nn.Conv2d(1, 8, kernel_size=3, padding=1), nn.ReLU(),
            nn.Conv2d(8, 16, kernel_size=3, padding=1), nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2), # 14x14

            nn.Conv2d(16, 32, kernel_size=3, padding=1), nn.ReLU(),
            nn.Conv2d(32, 32, kernel_size=3, padding=1), nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2), # 7x7

            nn.Conv2d(32, 32, kernel_size=3, padding=1), nn.ReLU(),
            nn.Conv2d(32, 32, kernel_size=3, padding=1), nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2), # 3x3
        )

        self.fc_layers = nn.Sequential(
            nn.Linear(32*3*3, 256), nn.ReLU(),
            nn.Linear(256, 10)  # Output Layer: 10 classes
        )

    def forward(self, x):
        x = self.conv_layers(x)
        x = x.view(x.size(0), -1) # Flatten tensor
        x = self.fc_layers(x)
        return x
```

Prepare Datasets

[18]:
```
# Defined composed transformation on the dataset
transform = transforms.Compose([
    transforms.Resize((28,28)),
    transforms.ToTensor(),
    transforms.Normalize((0.1307,), (0.3081,))
])

train_dataset = datasets.MNIST(root='./data', train=True, download=True, transform=transform)
test_dataset = datasets.MNIST(root='./data', train=False, download=True, transform=transform)

train_loader = DataLoader(train_dataset, batch_size=128, shuffle=True)
test_loader = DataLoader(test_dataset, batch_size=128, shuffle=False)

# Initialize Model, Loss Function and Optimizer
model = SmallVGG().to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=0.001)
```

Train and Evaluate

[22]:
```
def train_and_evaluate(model,
                       train_loader,
                       test_loader,
                       criterion,
                       optimizer,
                       num_epochs=100):

    # Record losses to plot
    train_losses = []
    test_losses = []

    for epoch in range(num_epochs):
        model.train()
        running_loss = 0.0
        for images, labels in tqdm(train_loader):
            images, labels = images.to(device), labels.to(device)

            optimizer.zero_grad()
            outputs = model(images)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()

            running_loss += loss.item() * len(images)
        train_losses.append(running_loss / len(train_loader))

        # Evaluate on test set
        model.eval()
        test_loss = 0.0
        with torch.no_grad():
            for images, labels in test_loader:
                images, labels = images.to(device), labels.to(device)
                outputs = model(images)
                loss = criterion(outputs, labels)
                test_loss += loss.item() * len(images)

        test_losses.append(test_loss / len(test_loader))
        print(f"Epoch[{epoch+1}/{num_epochs}, Train Loss:{train_losses[-1]:.4f}, Test Loss:{test_losses[-1]:.4f}")

    return train_losses, test_losses
```

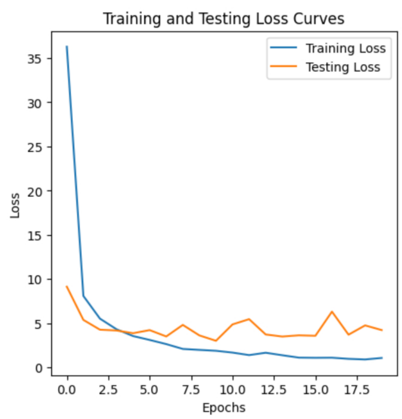
[23]:
```
num_epochs = 20
train_losses, test_losses = train_and_evaluate(model, train_loader, test_loader, criterion, optimizer, num_epochs)
```

```
100%|██████████| 469/469 [00:19<00:00, 23.90it/s]
Epoch[1/20, Train Loss:36.2943, Test Loss:9.1432
100%|██████████| 469/469 [00:19<00:00, 23.68it/s]
Epoch[2/20, Train Loss:8.0915, Test Loss:5.3832
100%|██████████| 469/469 [00:19<00:00, 23.82it/s]
Epoch[3/20, Train Loss:5.5270, Test Loss:4.2761
100%|██████████| 469/469 [00:19<00:00, 23.72it/s]
Epoch[4/20, Train Loss:4.3243, Test Loss:4.1856
100%|██████████| 469/469 [00:19<00:00, 24.61it/s]
Epoch[5/20, Train Loss:3.5566, Test Loss:3.8797
100%|██████████| 469/469 [00:18<00:00, 24.98it/s]
Epoch[6/20, Train Loss:3.1175, Test Loss:4.2280
100%|██████████| 469/469 [00:18<00:00, 25.44it/s]
Epoch[7/20, Train Loss:2.6472, Test Loss:3.5115
100%|██████████| 469/469 [00:19<00:00, 23.46it/s]
Epoch[8/20, Train Loss:2.1011, Test Loss:4.8168
100%|██████████| 469/469 [00:19<00:00, 23.50it/s]
Epoch[9/20, Train Loss:1.9912, Test Loss:3.6292
100%|██████████| 469/469 [00:19<00:00, 23.62it/s]
Epoch[10/20, Train Loss:1.8905, Test Loss:3.0222
100%|██████████| 469/469 [00:19<00:00, 23.60it/s]
Epoch[11/20, Train Loss:1.6861, Test Loss:4.8750
100%|██████████| 469/469 [00:19<00:00, 24.07it/s]
Epoch[12/20, Train Loss:1.4032, Test Loss:5.4678
100%|██████████| 469/469 [00:19<00:00, 24.28it/s]
Epoch[13/20, Train Loss:1.6684, Test Loss:3.7368
100%|██████████| 469/469 [00:18<00:00, 24.82it/s]
Epoch[14/20, Train Loss:1.3882, Test Loss:3.5021
100%|██████████| 469/469 [00:19<00:00, 24.18it/s]
Epoch[15/20, Train Loss:1.1176, Test Loss:3.6386
100%|██████████| 469/469 [00:19<00:00, 24.05it/s]
Epoch[16/20, Train Loss:1.0991, Test Loss:3.5877
100%|██████████| 469/469 [00:18<00:00, 24.73it/s]
Epoch[17/20, Train Loss:1.1092, Test Loss:6.3189
100%|██████████| 469/469 [00:19<00:00, 24.14it/s]
Epoch[18/20, Train Loss:0.9793, Test Loss:3.7140
100%|██████████| 469/469 [00:19<00:00, 23.87it/s]
Epoch[19/20, Train Loss:0.9093, Test Loss:4.7622
100%|██████████| 469/469 [00:19<00:00, 24.15it/s]
Epoch[20/20, Train Loss:1.0800, Test Loss:4.2345
```

Plot loss curves

[24]:

```
plt.figure(figsize=(5,5))
plt.plot(train_losses, label="Training Loss")
plt.plot(test_losses, label="Testing Loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.title("Training and Testing Loss Curves")
plt.legend()
plt.show()
```



[ ]: