Tanawin-st123975-vgg16

October 20, 2023

[ ]:
```
!nvidia-smi
```

```
Thu Oct 19 21:01:56 2023
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 525.105.17   Driver Version: 525.105.17   CUDA Version: 12.0     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|                               |                      |               MIG M. |
|===============================+======================+======================|
|   0  Tesla T4            Off  | 00000000:00:04.0 Off |                    0 |
| N/A   57C    P0    29W /  70W |   3263MiB / 15360MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
+-----------------------------------------------------------------------------+
```

[ ]:
```
import torch
import torch.nn as nn
import torch.nn.functional as F
import torchvision
import torchvision.transforms as transforms
from torch.utils.data import DataLoader
import seaborn as sns
import numpy as np
from torch.utils.data import random_split
device=torch.device('cuda' if torch.cuda.is_available() else 'cpu')
```

[ ]:
```
transform_train = transforms.Compose([
    transforms.RandomCrop(32, padding=4),
    transforms.RandomHorizontalFlip(),
    transforms.ToTensor(),
    transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
```

```
])

# transform_train = transforms.Compose([
#     transforms.RandomResizedCrop(224),
#     transforms.RandomHorizontalFlip(),
#     transforms.ToTensor(),
#     transforms.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.
 ↪225])
# ])

# Normalization for testing, no data augmentation
transform_test = transforms.Compose([
    transforms.ToTensor(),
    transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
])

# transform_train = transforms.Compose([
#     transforms.RandomResizedCrop(32, scale=(0.8, 1.0)),
#     transforms.RandomHorizontalFlip(),
#     transforms.ColorJitter(brightness=0.4, contrast=0.4, saturation=0.4,␣
 ↪hue=0.1),
#     transforms.RandomRotation(20),
#     transforms.ToTensor(),
#     transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
# ])

# transform_test = transforms.Compose([
#     transforms.ToTensor(),
#     transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
# ])


batch_size = 8

# Load CIFAR-10 dataset
trainset = torchvision.datasets.CIFAR10(root='./data', train=True,
                                        download=True,␣
 ↪transform=transform_train)
trainloader = torch.utils.data.DataLoader(trainset, batch_size=batch_size,
                                          shuffle=True, num_workers=32)

testset = torchvision.datasets.CIFAR10(root='./data', train=False,
                                       download=True, transform=transform_test)
testloader = torch.utils.data.DataLoader(testset, batch_size=batch_size,
                                         shuffle=False, num_workers=32)
```

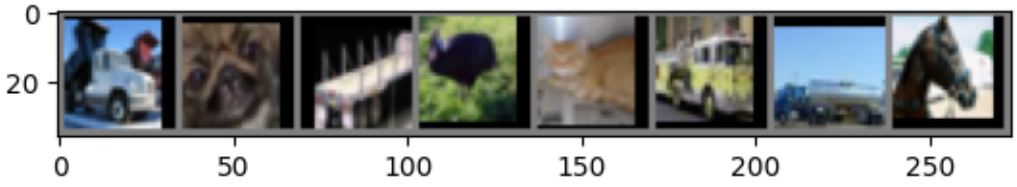
```
classes = ('plane', 'car', 'bird', 'cat',
           'deer', 'dog', 'frog', 'horse', 'ship', 'truck')
```

```
Files already downloaded and verified
```

```
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:560:
UserWarning: This DataLoader will create 32 worker processes in total. Our
suggested max number of worker in current system is 8, which is smaller than
what this DataLoader is going to create. Please be aware that excessive worker
creation might get DataLoader running slow or even freeze, lower the worker
number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```

```
Files already downloaded and verified
```

[ ]:
```
import matplotlib.pyplot as plt
import numpy as np

# functions to show an image


def imshow(img):
    img = img / 2 + 0.5     # unnormalize
    npimg = img.numpy()
    plt.imshow(np.transpose(npimg, (1, 2, 0)))
    plt.show()


# get some random training images
dataiter = iter(trainloader)
images, labels = next(dataiter)

# show images
imshow(torchvision.utils.make_grid(images))
# print labels
print(' '.join(f'{classes[labels[j]]:5s}' for j in range(batch_size)))
```




```
truck dog   truck bird  cat   truck truck horse
```

[ ]:
```
# import torch
# import torch.nn as nn
# import torch.nn.functional as F

# class VGG16_NET(nn.Module):
#     def __init__(self):
#         super(VGG16_NET, self).__init__()
#         self.conv1 = nn.Conv2d(in_channels=3, out_channels=64, kernel_size=3,␣
 ↪padding=1)
#         self.bn1 = nn.BatchNorm2d(64)
#         self.conv2 = nn.Conv2d(in_channels=64, out_channels=64,␣
 ↪kernel_size=3, padding=1)
#         self.bn2 = nn.BatchNorm2d(64)

#         self.conv3 = nn.Conv2d(in_channels=64, out_channels=128,␣
 ↪kernel_size=3, padding=1)
#         self.bn3 = nn.BatchNorm2d(128)
#         self.conv4 = nn.Conv2d(in_channels=128, out_channels=128,␣
 ↪kernel_size=3, padding=1)
#         self.bn4 = nn.BatchNorm2d(128)

#         self.conv5 = nn.Conv2d(in_channels=128, out_channels=256,␣
 ↪kernel_size=3, padding=1)
#         self.bn5 = nn.BatchNorm2d(256)
#         self.conv6 = nn.Conv2d(in_channels=256, out_channels=256,␣
 ↪kernel_size=3, padding=1)
#         self.bn6 = nn.BatchNorm2d(256)
#         self.conv7 = nn.Conv2d(in_channels=256, out_channels=256,␣
 ↪kernel_size=3, padding=1)
#         self.bn7 = nn.BatchNorm2d(256)

#         self.conv8 = nn.Conv2d(in_channels=256, out_channels=512,␣
 ↪kernel_size=3, padding=1)
#         self.bn8 = nn.BatchNorm2d(512)
#         self.conv9 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
#         self.bn9 = nn.BatchNorm2d(512)
#         self.conv10 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
#         self.bn10 = nn.BatchNorm2d(512)

#         self.conv11 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
#         self.bn11 = nn.BatchNorm2d(512)
#         self.conv12 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
```

```
#         self.bn12 = nn.BatchNorm2d(512)
#         self.conv13 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
#         self.bn13 = nn.BatchNorm2d(512)

#         self.maxpool = nn.MaxPool2d(kernel_size=2, stride=2)

#         self.fc14 = nn.Linear(512, 4096)
#         self.fc15 = nn.Linear(4096, 4096)
#         self.fc16 = nn.Linear(4096, 10)

#     def forward(self, x):
#         x = F.relu(self.bn1(self.conv1(x)))
#         x = F.relu(self.bn2(self.conv2(x)))
#         x = self.maxpool(x)
#         x = F.relu(self.bn3(self.conv3(x)))
#         x = F.relu(self.bn4(self.conv4(x)))
#         x = self.maxpool(x)
#         x = F.relu(self.bn5(self.conv5(x)))
#         x = F.relu(self.bn6(self.conv6(x)))
#         x = F.relu(self.bn7(self.conv7(x)))
#         x = self.maxpool(x)
#         x = F.relu(self.bn8(self.conv8(x)))
#         x = F.relu(self.bn9(self.conv9(x)))
#         x = F.relu(self.bn10(self.conv10(x)))
#         x = self.maxpool(x)
#         x = F.relu(self.bn11(self.conv11(x)))
#         x = F.relu(self.bn12(self.conv12(x)))
#         x = F.relu(self.bn13(self.conv13(x)))
#         x = self.maxpool(x)

#         x = x.view(x.size(0), -1)
#         x = F.relu(self.fc14(x))
#         x = F.dropout(x, 0.5)
#         x = F.relu(self.fc15(x))
#         x = F.dropout(x, 0.5)
#         x = self.fc16(x)
#         return x

# # Create an instance of the combined model
# device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
# model = VGG16_NET()
# model.to(device)
```

[ ]:
```
import torch
import torch.nn as nn
import torch.nn.functional as F
```

```
class VGG16_NET(nn.Module):
    def __init__(self):
        super(VGG16_NET, self).__init__()
        self.conv1 = nn.Conv2d(in_channels=3, out_channels=64, kernel_size=3,␣
 ↪padding=1)
        self.bn1 = nn.BatchNorm2d(64)
        self.conv2 = nn.Conv2d(in_channels=64, out_channels=64, kernel_size=3,␣
 ↪padding=1)
        self.bn2 = nn.BatchNorm2d(64)

        self.conv3 = nn.Conv2d(in_channels=64, out_channels=128, kernel_size=3,␣
 ↪padding=1)
        self.bn3 = nn.BatchNorm2d(128)
        self.conv4 = nn.Conv2d(in_channels=128, out_channels=128,␣
 ↪kernel_size=3, padding=1)
        self.bn4 = nn.BatchNorm2d(128)

        self.conv5 = nn.Conv2d(in_channels=128, out_channels=256,␣
 ↪kernel_size=3, padding=1)
        self.bn5 = nn.BatchNorm2d(256)
        self.conv6 = nn.Conv2d(in_channels=256, out_channels=256,␣
 ↪kernel_size=3, padding=1)
        self.bn6 = nn.BatchNorm2d(256)
        self.conv7 = nn.Conv2d(in_channels=256, out_channels=256,␣
 ↪kernel_size=3, padding=1)
        self.bn7 = nn.BatchNorm2d(256)

        self.conv8 = nn.Conv2d(in_channels=256, out_channels=512,␣
 ↪kernel_size=3, padding=1)
        self.bn8 = nn.BatchNorm2d(512)
        self.conv9 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
        self.bn9 = nn.BatchNorm2d(512)
        self.conv10 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
        self.bn10 = nn.BatchNorm2d(512)

        self.conv11 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
        self.bn11 = nn.BatchNorm2d(512)
        self.conv12 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
        self.bn12 = nn.BatchNorm2d(512)
        self.conv13 = nn.Conv2d(in_channels=512, out_channels=512,␣
 ↪kernel_size=3, padding=1)
```

```
        self.bn13 = nn.BatchNorm2d(512)

        self.maxpool = nn.MaxPool2d(kernel_size=2, stride=2)

        self.fc14 = nn.Linear(512, 4096)
        self.dropout1 = nn.Dropout(0.5)
        self.fc15 = nn.Linear(4096, 4096)
        self.dropout2 = nn.Dropout(0.5)
        self.fc16 = nn.Linear(4096, 10)

    def forward(self, x):
        x = F.relu(self.bn1(self.conv1(x)))
        x = F.relu(self.bn2(self.conv2(x)))
        x = self.maxpool(x)
        x = F.relu(self.bn3(self.conv3(x)))
        x = F.relu(self.bn4(self.conv4(x)))
        x = self.maxpool(x)
        x = F.relu(self.bn5(self.conv5(x)))
        x = F.relu(self.bn6(self.conv6(x)))
        x = F.relu(self.bn7(self.conv7(x)))
        x = self.maxpool(x)
        x = F.relu(self.bn8(self.conv8(x)))
        x = F.relu(self.bn9(self.conv9(x)))
        x = F.relu(self.bn10(self.conv10(x)))
        x = self.maxpool(x)
        x = F.relu(self.bn11(self.conv11(x)))
        x = F.relu(self.bn12(self.conv12(x)))
        x = F.relu(self.bn13(self.conv13(x)))
        x = self.maxpool(x)

        x = x.view(x.size(0), -1)
        x = F.relu(self.fc14(x))
        x = self.dropout1(x)
        x = F.relu(self.fc15(x))
        x = self.dropout2(x)
        x = self.fc16(x)
        return x

# Create an instance of the combined model
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model = VGG16_NET()
model.to(device)
```

[ ]:
```
VGG16_NET(
  (conv1): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
```

```
  (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv3): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn3): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv4): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn4): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv5): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn5): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv6): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn6): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv7): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn7): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv8): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn8): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv9): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn9): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv10): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn10): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv11): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn11): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv12): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn12): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (conv13): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (bn13): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
  (maxpool): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  (fc14): Linear(in_features=512, out_features=4096, bias=True)
  (dropout1): Dropout(p=0.5, inplace=False)
  (fc15): Linear(in_features=4096, out_features=4096, bias=True)
  (dropout2): Dropout(p=0.5, inplace=False)
  (fc16): Linear(in_features=4096, out_features=10, bias=True)
)
```

[ ]:
```
# model._dropout = nn.Dropout(p=0.5)
```

[ ]:
```
import torch.optim as optim

criterion = nn.CrossEntropyLoss()

# optimizer = optim.SGD(model.parameters(), lr=0.001, momentum=0.9,␣
 ↪weight_decay=0.0001)
# optimizer = optim.RMSprop(model.parameters(), lr=0.001, alpha=0.9,␣
 ↪weight_decay=0.0001)
optimizer = optim.Adam(model.parameters(), lr=0.001, weight_decay=0.0001)
```

[ ]:
```
from torch.optim.lr_scheduler import ExponentialLR, MultiStepLR

scheduler = optim.lr_scheduler.StepLR(optimizer, step_size=5, gamma=0.1)

scheduler1 = ExponentialLR(optimizer, gamma=0.9)
scheduler2 = MultiStepLR(optimizer, milestones=[30,80], gamma=0.1)
```

[ ]:
```
model_name = "vgg16_scratch"
# Training loop
num_epochs = 50
train_loss_list = []
valid_loss_list = []
train_accuracy_list = []
valid_accuracy_list = []

for epoch in range(num_epochs):
    model.train()
    running_loss = 0.0
    correct = 0
    total = 0

    for images, labels in trainloader:
        images = images.to(device)
        labels = labels.to(device)

        optimizer.zero_grad()

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

        running_loss += loss.item()
        _, predicted = torch.max(outputs, 1)
        total += labels.size(0)
        correct += (predicted == labels).sum().item()
```

```
    train_loss = running_loss / len(trainloader)
    train_accuracy = correct / total

    # Validation loop
    model.eval()
    running_loss = 0.0
    correct = 0
    total = 0

    with torch.no_grad():
        for images, labels in testloader:
            images = images.to(device)
            labels = labels.to(device)

            outputs = model(images)
            loss = criterion(outputs, labels)

            running_loss += loss.item()
            _, predicted = torch.max(outputs, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()

    valid_loss = running_loss / len(testloader)
    valid_accuracy = correct / total

    # Store loss and accuracy values
    train_loss_list.append(train_loss)
    valid_loss_list.append(valid_loss)
    train_accuracy_list.append(train_accuracy)
    valid_accuracy_list.append(valid_accuracy)

    # Print the training/validation statistics
    print(f"Epoch: {epoch+1}/{num_epochs} | "
          f"Train Loss: {train_loss:.4f} | Train Acc: {train_accuracy:.4f} | "
          f"Valid Loss: {valid_loss:.4f} | Valid Acc: {valid_accuracy:.4f}")

    # Update the learning rate
    # scheduler.step()
    scheduler1.step()
    scheduler2.step()

# Save the trained model
torch.save(model.state_dict(), model_name+".pth")
```

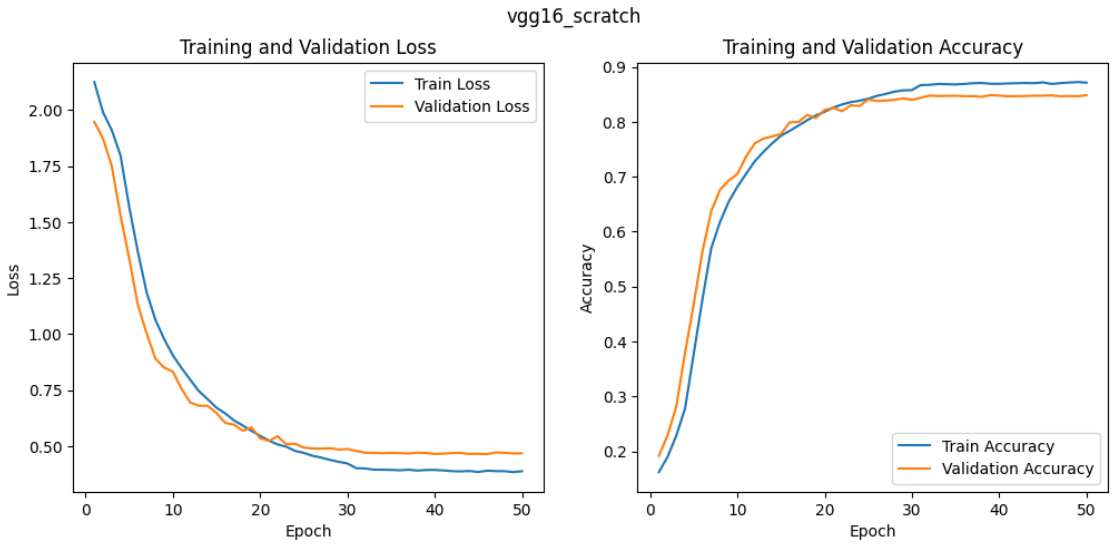
```
Epoch: 1/50 | Train Loss: 2.1251 | Train Acc: 0.1621 | Valid Loss: 1.9477 |
Valid Acc: 0.1917
Epoch: 2/50 | Train Loss: 1.9899 | Train Acc: 0.1898 | Valid Loss: 1.8724 |
```

```
Valid Acc: 0.2290
Epoch: 3/50 | Train Loss: 1.9107 | Train Acc: 0.2286 | Valid Loss: 1.7506 |
Valid Acc: 0.2818
Epoch: 4/50 | Train Loss: 1.7977 | Train Acc: 0.2776 | Valid Loss: 1.5297 |
Valid Acc: 0.3790
Epoch: 5/50 | Train Loss: 1.5679 | Train Acc: 0.3777 | Valid Loss: 1.3371 |
Valid Acc: 0.4682
Epoch: 6/50 | Train Loss: 1.3651 | Train Acc: 0.4771 | Valid Loss: 1.1292 |
Valid Acc: 0.5640
Epoch: 7/50 | Train Loss: 1.1854 | Train Acc: 0.5696 | Valid Loss: 1.0025 |
Valid Acc: 0.6371
Epoch: 8/50 | Train Loss: 1.0637 | Train Acc: 0.6171 | Valid Loss: 0.8898 |
Valid Acc: 0.6758
Epoch: 9/50 | Train Loss: 0.9780 | Train Acc: 0.6542 | Valid Loss: 0.8506 |
Valid Acc: 0.6928
Epoch: 10/50 | Train Loss: 0.9052 | Train Acc: 0.6816 | Valid Loss: 0.8321 |
Valid Acc: 0.7051
Epoch: 11/50 | Train Loss: 0.8479 | Train Acc: 0.7052 | Valid Loss: 0.7546 |
Valid Acc: 0.7368
Epoch: 12/50 | Train Loss: 0.7956 | Train Acc: 0.7281 | Valid Loss: 0.6937 |
Valid Acc: 0.7607
Epoch: 13/50 | Train Loss: 0.7444 | Train Acc: 0.7454 | Valid Loss: 0.6799 |
Valid Acc: 0.7693
Epoch: 14/50 | Train Loss: 0.7087 | Train Acc: 0.7608 | Valid Loss: 0.6796 |
Valid Acc: 0.7733
Epoch: 15/50 | Train Loss: 0.6712 | Train Acc: 0.7746 | Valid Loss: 0.6472 |
Valid Acc: 0.7776
Epoch: 16/50 | Train Loss: 0.6456 | Train Acc: 0.7834 | Valid Loss: 0.6030 |
Valid Acc: 0.7989
Epoch: 17/50 | Train Loss: 0.6143 | Train Acc: 0.7931 | Valid Loss: 0.5960 |
Valid Acc: 0.7996
Epoch: 18/50 | Train Loss: 0.5920 | Train Acc: 0.8027 | Valid Loss: 0.5684 |
Valid Acc: 0.8123
Epoch: 19/50 | Train Loss: 0.5678 | Train Acc: 0.8115 | Valid Loss: 0.5836 |
Valid Acc: 0.8068
Epoch: 20/50 | Train Loss: 0.5457 | Train Acc: 0.8181 | Valid Loss: 0.5346 |
Valid Acc: 0.8215
Epoch: 21/50 | Train Loss: 0.5244 | Train Acc: 0.8258 | Valid Loss: 0.5224 |
Valid Acc: 0.8253
Epoch: 22/50 | Train Loss: 0.5073 | Train Acc: 0.8314 | Valid Loss: 0.5436 |
Valid Acc: 0.8190
Epoch: 23/50 | Train Loss: 0.4969 | Train Acc: 0.8357 | Valid Loss: 0.5074 |
Valid Acc: 0.8301
Epoch: 24/50 | Train Loss: 0.4781 | Train Acc: 0.8381 | Valid Loss: 0.5102 |
Valid Acc: 0.8284
Epoch: 25/50 | Train Loss: 0.4696 | Train Acc: 0.8419 | Valid Loss: 0.4934 |
Valid Acc: 0.8406
Epoch: 26/50 | Train Loss: 0.4563 | Train Acc: 0.8472 | Valid Loss: 0.4893 |
```

```
Valid Acc: 0.8377
Epoch: 27/50 | Train Loss: 0.4483 | Train Acc: 0.8505 | Valid Loss: 0.4887 |
Valid Acc: 0.8386
Epoch: 28/50 | Train Loss: 0.4380 | Train Acc: 0.8547 | Valid Loss: 0.4899 |
Valid Acc: 0.8398
Epoch: 29/50 | Train Loss: 0.4296 | Train Acc: 0.8570 | Valid Loss: 0.4844 |
Valid Acc: 0.8425
Epoch: 30/50 | Train Loss: 0.4222 | Train Acc: 0.8576 | Valid Loss: 0.4867 |
Valid Acc: 0.8399
Epoch: 31/50 | Train Loss: 0.4013 | Train Acc: 0.8667 | Valid Loss: 0.4783 |
Valid Acc: 0.8434
Epoch: 32/50 | Train Loss: 0.4000 | Train Acc: 0.8671 | Valid Loss: 0.4704 |
Valid Acc: 0.8476
Epoch: 33/50 | Train Loss: 0.3948 | Train Acc: 0.8687 | Valid Loss: 0.4695 |
Valid Acc: 0.8468
Epoch: 34/50 | Train Loss: 0.3943 | Train Acc: 0.8683 | Valid Loss: 0.4681 |
Valid Acc: 0.8470
Epoch: 35/50 | Train Loss: 0.3935 | Train Acc: 0.8679 | Valid Loss: 0.4691 |
Valid Acc: 0.8472
Epoch: 36/50 | Train Loss: 0.3917 | Train Acc: 0.8687 | Valid Loss: 0.4685 |
Valid Acc: 0.8464
Epoch: 37/50 | Train Loss: 0.3945 | Train Acc: 0.8701 | Valid Loss: 0.4665 |
Valid Acc: 0.8466
Epoch: 38/50 | Train Loss: 0.3905 | Train Acc: 0.8706 | Valid Loss: 0.4703 |
Valid Acc: 0.8453
Epoch: 39/50 | Train Loss: 0.3931 | Train Acc: 0.8691 | Valid Loss: 0.4689 |
Valid Acc: 0.8483
Epoch: 40/50 | Train Loss: 0.3934 | Train Acc: 0.8690 | Valid Loss: 0.4646 |
Valid Acc: 0.8476
Epoch: 41/50 | Train Loss: 0.3911 | Train Acc: 0.8697 | Valid Loss: 0.4662 |
Valid Acc: 0.8463
Epoch: 42/50 | Train Loss: 0.3877 | Train Acc: 0.8702 | Valid Loss: 0.4686 |
Valid Acc: 0.8465
Epoch: 43/50 | Train Loss: 0.3869 | Train Acc: 0.8704 | Valid Loss: 0.4694 |
Valid Acc: 0.8468
Epoch: 44/50 | Train Loss: 0.3886 | Train Acc: 0.8702 | Valid Loss: 0.4647 |
Valid Acc: 0.8473
Epoch: 45/50 | Train Loss: 0.3842 | Train Acc: 0.8716 | Valid Loss: 0.4653 |
Valid Acc: 0.8474
Epoch: 46/50 | Train Loss: 0.3899 | Train Acc: 0.8687 | Valid Loss: 0.4638 |
Valid Acc: 0.8479
Epoch: 47/50 | Train Loss: 0.3882 | Train Acc: 0.8702 | Valid Loss: 0.4713 |
Valid Acc: 0.8463
Epoch: 48/50 | Train Loss: 0.3877 | Train Acc: 0.8714 | Valid Loss: 0.4700 |
Valid Acc: 0.8467
Epoch: 49/50 | Train Loss: 0.3836 | Train Acc: 0.8722 | Valid Loss: 0.4670 |
Valid Acc: 0.8464
Epoch: 50/50 | Train Loss: 0.3875 | Train Acc: 0.8711 | Valid Loss: 0.4675 |
```

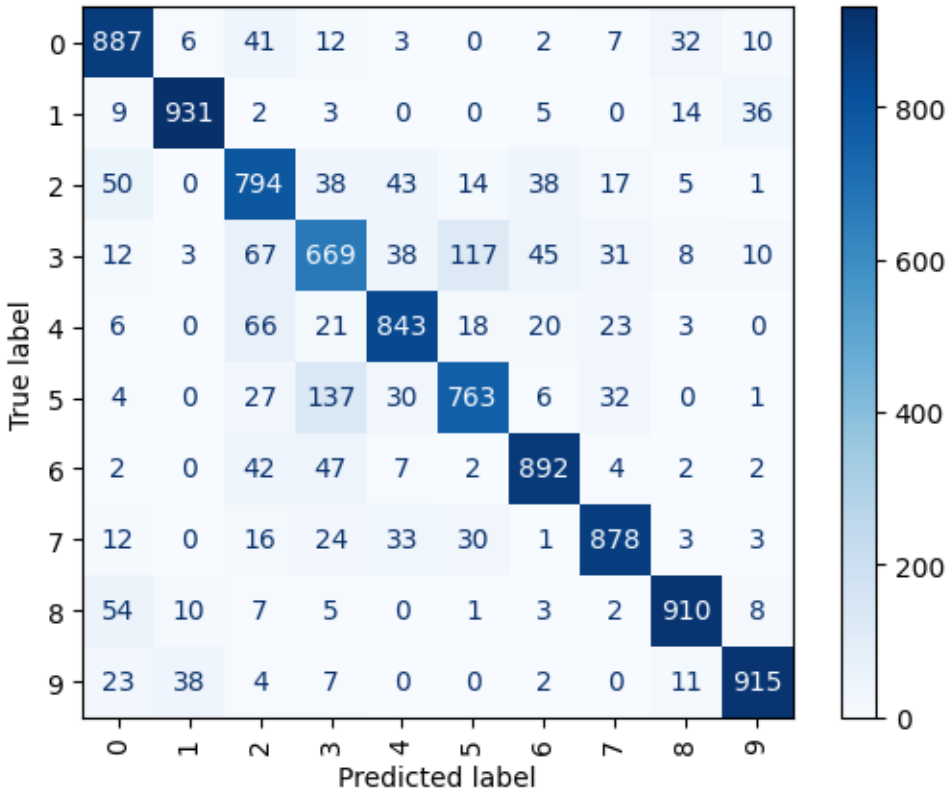
```
Valid Acc: 0.8482
```

[ ]:
```
import matplotlib.pyplot as plt
plt.figure(figsize=(12, 5))
plt.subplot(1, 2, 1)
# Plot training and validation loss
plt.plot(range(1, num_epochs+1), train_loss_list, label='Train Loss')
plt.plot(range(1, num_epochs+1), valid_loss_list, label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training and Validation Loss')
plt.legend()

plt.subplot(1, 2, 2)
# Plot training and validation accuracy
plt.plot(range(1, num_epochs+1), train_accuracy_list, label='Train Accuracy')
plt.plot(range(1, num_epochs+1), valid_accuracy_list, label='Validation␣
 ↪Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.title('Training and Validation Accuracy')
plt.legend()

plt.suptitle(model_name)
plt.show()
```



[ ]:
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import numpy as np
```

```
loaded_model = VGG16_NET()
loaded_model.load_state_dict(torch.load('/content/vgg16_scratch.pth'))
loaded_model.to(device)  # Move the loaded model to the same device as the data

# Test the loaded model
def test_loaded_model(model, test_dataloader, device):
    model.eval()  # Set the model to evaluation mode
    all_preds = []
    all_labels = []
    with torch.no_grad():
        for inputs, labels in test_dataloader:
            inputs = inputs.to(device)
            labels = labels.to(device)
            outputs = model(inputs)
            _, preds = torch.max(outputs, 1)
            all_preds.extend(preds.cpu().numpy())
            all_labels.extend(labels.cpu().numpy())
    return all_preds, all_labels

# Test the loaded model
all_preds, all_labels = test_loaded_model(loaded_model, testloader, device)

# Generate confusion matrix
cm = confusion_matrix(all_labels, all_preds)

# Display the confusion matrix using ConfusionMatrixDisplay
cmd = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=np.
 ↪unique(all_labels))
cmd.plot(cmap='Blues', xticks_rotation='vertical')

# Show the plot
plt.show()
```


True label
Predicted label
0 887 6 41 12 3 0 2 7 32 10
1 9 931 2 3 0 0 5 0 14 36
2 50 0 794 38 43 14 38 17 5 1
3 12 3 67 669 38 117 45 31 8 10
4 6 0 66 21 843 18 20 23 3 0
5 4 0 27 137 30 763 6 32 0 1
6 2 0 42 47 7 2 892 4 2 2
7 12 0 16 24 33 30 1 878 3 3
8 54 10 7 5 0 1 3 2 910 8
9 23 38 4 7 0 0 2 0 11 915
0 1 2 3 4 5 6 7 8 9
800
600
400
200
0