Tanawin-st123975-Inceptionv3

October 20, 2023

[1]:
```
!nvidia-smi
```

```
Fri Oct 20 03:28:49 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   43C    P8     9W /  70W |      0MiB / 15360MiB |      0%      Default |
|                               |                      |                  N/A |
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+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
```

[2]:
```
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')
```

[3]:
```
# 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(299),
#     transforms.RandomHorizontalFlip(),
#     transforms.ToTensor(),
#     transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
# ])


# # 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))
# ])

# Define transformations for the dataset
transform_train = transforms.Compose([
    transforms.Resize((299, 299)),
    transforms.ToTensor(),
])

transform_test = transforms.Compose([
    transforms.Resize((299, 299)),
    transforms.ToTensor(),
])

batch_size = 4

# 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=2)

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=2)



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

```
Downloading https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz to
```

```
./data/cifar-10-python.tar.gz

100%|          | 170498071/170498071 [00:02<00:00, 80622033.34it/s]

Extracting ./data/cifar-10-python.tar.gz to ./data
Files already downloaded and verified
```

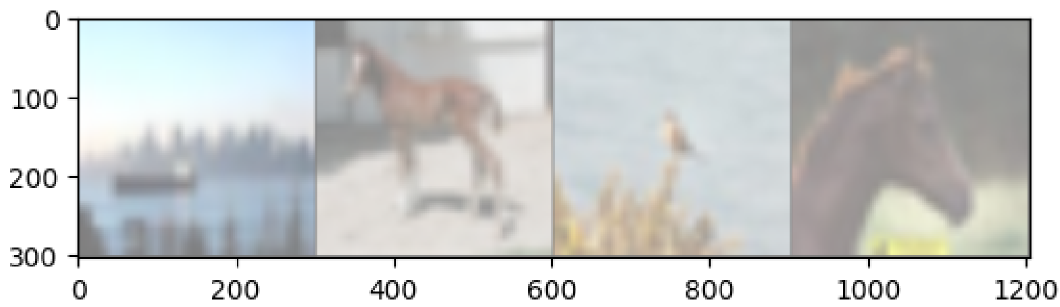
[4]:
```python
import matplotlib.pyplot as plt
import numpy as np

# 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)))
```



[5]:
```python
import torch
import torchvision
import torchvision.transforms as transforms
import torch.optim as optim
import torch.nn as nn

class BasicConv2d(nn.Module):
```

```
    def __init__(self, in_channels, out_channels, **kwargs):
        super(BasicConv2d, self).__init__()
        self.conv = nn.Conv2d(in_channels, out_channels, bias=False, **kwargs)
        self.bn = nn.BatchNorm2d(out_channels, eps=0.001)

    def forward(self, x):
        x = self.conv(x)
        x = self.bn(x)
        return nn.functional.relu(x, inplace=True)

class InceptionA(nn.Module):
    def __init__(self, in_channels, pool_features):
        super(InceptionA, self).__init__()
        self.branch1x1 = BasicConv2d(in_channels, 64, kernel_size=1)

        self.branch5x5_1 = BasicConv2d(in_channels, 48, kernel_size=1)
        self.branch5x5_2 = BasicConv2d(48, 64, kernel_size=5, padding=2)

        self.branch3x3dbl_1 = BasicConv2d(in_channels, 64, kernel_size=1)
        self.branch3x3dbl_2 = BasicConv2d(64, 96, kernel_size=3, padding=1)
        self.branch3x3dbl_3 = BasicConv2d(96, 96, kernel_size=3, padding=1)

        self.branch_pool = BasicConv2d(in_channels, pool_features,␣
↪kernel_size=1)

    def forward(self, x):
        branch1x1 = self.branch1x1(x)

        branch5x5 = self.branch5x5_1(x)
        branch5x5 = self.branch5x5_2(branch5x5)

        branch3x3dbl = self.branch3x3dbl_1(x)
        branch3x3dbl = self.branch3x3dbl_2(branch3x3dbl)
        branch3x3dbl = self.branch3x3dbl_3(branch3x3dbl)

        branch_pool = nn.functional.avg_pool2d(x, kernel_size=3, stride=1,␣
↪padding=1)
        branch_pool = self.branch_pool(branch_pool)

        outputs = [branch1x1, branch5x5, branch3x3dbl, branch_pool]
        return torch.cat(outputs, 1)


class InceptionB(nn.Module):
    def __init__(self, in_channels):
        super(InceptionB, self).__init__()
        self.branch3x3 = BasicConv2d(in_channels, 384, kernel_size=3, stride=2)
```

```
        self.branch3x3dbl_1 = BasicConv2d(in_channels, 64, kernel_size=1)
        self.branch3x3dbl_2 = BasicConv2d(64, 96, kernel_size=3, padding=1)
        self.branch3x3dbl_3 = BasicConv2d(96, 96, kernel_size=3, stride=2)

    def forward(self, x):
        branch3x3 = self.branch3x3(x)

        branch3x3dbl = self.branch3x3dbl_1(x)
        branch3x3dbl = self.branch3x3dbl_2(branch3x3dbl)
        branch3x3dbl = self.branch3x3dbl_3(branch3x3dbl)

        branch_pool = nn.functional.max_pool2d(x, kernel_size=3, stride=2)

        outputs = [branch3x3, branch3x3dbl, branch_pool]
        return torch.cat(outputs, 1)


class InceptionC(nn.Module):
    def __init__(self, in_channels, channels_7x7):
        super(InceptionC, self).__init__()
        self.branch1x1 = BasicConv2d(in_channels, 192, kernel_size=1)

        c7 = channels_7x7
        self.branch7x7_1 = BasicConv2d(in_channels, c7, kernel_size=1)
        self.branch7x7_2 = BasicConv2d(c7, c7, kernel_size=(1, 7), padding=(0, 3))
        self.branch7x7_3 = BasicConv2d(c7, 192, kernel_size=(7, 1), padding=(3, 0))

        self.branch7x7dbl_1 = BasicConv2d(in_channels, c7, kernel_size=1)
        self.branch7x7dbl_2 = BasicConv2d(c7, c7, kernel_size=(7, 1), padding=(3, 0))
        self.branch7x7dbl_3 = BasicConv2d(c7, c7, kernel_size=(1, 7), padding=(0, 3))
        self.branch7x7dbl_4 = BasicConv2d(c7, c7, kernel_size=(7, 1), padding=(3, 0))
        self.branch7x7dbl_5 = BasicConv2d(c7, 192, kernel_size=(1, 7), padding=(0, 3))

        self.branch_pool = BasicConv2d(in_channels, 192, kernel_size=1)

    def forward(self, x):
        branch1x1 = self.branch1x1(x)

        branch7x7 = self.branch7x7_1(x)
```

```
        branch7x7 = self.branch7x7_2(branch7x7)
        branch7x7 = self.branch7x7_3(branch7x7)

        branch7x7dbl = self.branch7x7dbl_1(x)
        branch7x7dbl = self.branch7x7dbl_2(branch7x7dbl)
        branch7x7dbl = self.branch7x7dbl_3(branch7x7dbl)
        branch7x7dbl = self.branch7x7dbl_4(branch7x7dbl)
        branch7x7dbl = self.branch7x7dbl_5(branch7x7dbl)

        branch_pool = nn.functional.avg_pool2d(x, kernel_size=3, stride=1,␣
 ↪padding=1)
        branch_pool = self.branch_pool(branch_pool)

        outputs = [branch1x1, branch7x7, branch7x7dbl, branch_pool]
        return torch.cat(outputs, 1)


class InceptionD(nn.Module):
    def __init__(self, in_channels):
        super(InceptionD, self).__init__()
        self.branch3x3_1 = BasicConv2d(in_channels, 192, kernel_size=1)
        self.branch3x3_2 = BasicConv2d(192, 320, kernel_size=3, stride=2)

        self.branch7x7x3_1 = BasicConv2d(in_channels, 192, kernel_size=1)
        self.branch7x7x3_2 = BasicConv2d(192, 192, kernel_size=(1, 7),␣
 ↪padding=(0, 3))
        self.branch7x7x3_3 = BasicConv2d(192, 192, kernel_size=(7, 1),␣
 ↪padding=(3, 0))
        self.branch7x7x3_4 = BasicConv2d(192, 192, kernel_size=3, stride=2)

    def forward(self, x):
        branch3x3 = self.branch3x3_1(x)
        branch3x3 = self.branch3x3_2(branch3x3)

        branch7x7x3 = self.branch7x7x3_1(x)
        branch7x7x3 = self.branch7x7x3_2(branch7x7x3)
        branch7x7x3 = self.branch7x7x3_3(branch7x7x3)
        branch7x7x3 = self.branch7x7x3_4(branch7x7x3)

        branch_pool = nn.functional.max_pool2d(x, kernel_size=3, stride=2)

        outputs = [branch3x3, branch7x7x3, branch_pool]
        return torch.cat(outputs, 1)


class InceptionE(nn.Module):
    def __init__(self, in_channels):
```

```python
        super(InceptionE, self).__init__()
        self.branch1x1 = BasicConv2d(in_channels, 320, kernel_size=1)

        self.branch3x3_1 = BasicConv2d(in_channels, 384, kernel_size=1)
        self.branch3x3_2a = BasicConv2d(384, 384, kernel_size=(1, 3),␣
↪padding=(0, 1))
        self.branch3x3_2b = BasicConv2d(384, 384, kernel_size=(3, 1),␣
↪padding=(1, 0))

        self.branch3x3dbl_1 = BasicConv2d(in_channels, 448, kernel_size=1)
        self.branch3x3dbl_2 = BasicConv2d(448, 384, kernel_size=3, padding=1)
        self.branch3x3dbl_3a = BasicConv2d(384, 384, kernel_size=(1, 3),␣
↪padding=(0, 1))
        self.branch3x3dbl_3b = BasicConv2d(384, 384, kernel_size=(3, 1),␣
↪padding=(1, 0))

        self.branch_pool = BasicConv2d(in_channels, 192, kernel_size=1)

    def forward(self, x):
        branch1x1 = self.branch1x1(x)

        branch3x3 = self.branch3x3_1(x)
        branch3x3 = [
            self.branch3x3_2a(branch3x3),
            self.branch3x3_2b(branch3x3)
        ]
        branch3x3 = torch.cat(branch3x3, 1)

        branch3x3dbl = self.branch3x3dbl_1(x)
        branch3x3dbl = self.branch3x3dbl_2(branch3x3dbl)
        branch3x3dbl = [
            self.branch3x3dbl_3a(branch3x3dbl),
            self.branch3x3dbl_3b(branch3x3dbl)
        ]
        branch3x3dbl = torch.cat(branch3x3dbl, 1)

        branch_pool = nn.functional.avg_pool2d(x, kernel_size=3, stride=1,␣
↪padding=1)
        branch_pool = self.branch_pool(branch_pool)

        outputs = [branch1x1, branch3x3, branch3x3dbl, branch_pool]
        return torch.cat(outputs, 1)

class InceptionAux(nn.Module):
    def __init__(self, in_channels, num_classes):
        super(InceptionAux, self).__init__()
        self.average_pooling = nn.AvgPool2d(kernel_size=5, stride=3)
```

```
        self.conv1 = BasicConv2d(in_channels, 128, kernel_size=1)
        self.conv2 = BasicConv2d(128, 768, kernel_size=5)
        self.fc1 = nn.Linear(768, 1024)
        self.fc2 = nn.Linear(1024, num_classes)

    def forward(self, x):
        x = self.average_pooling(x)
        x = self.conv1(x)
        x = self.conv2(x)
        x = nn.functional.avg_pool2d(x, kernel_size=x.size(2))
        x = x.view(x.size(0), -1)
        x = nn.functional.relu(self.fc1(x), inplace=True)
        x = self.fc2(x)
        return x


class InceptionV3(nn.Module):
    def __init__(self, num_classes=1000, aux_logits=False, transform_input=False):
        super(InceptionV3, self).__init__()
        self.transform_input = transform_input
        self.aux_logits = aux_logits

        # Define the layers here
        self.Conv2d_1a_3x3 = BasicConv2d(3, 32, kernel_size=3, stride=2)
        self.Conv2d_2a_3x3 = BasicConv2d(32, 32, kernel_size=3)
        self.Conv2d_2b_3x3 = BasicConv2d(32, 64, kernel_size=3, padding=1)
        self.Conv2d_3b_1x1 = BasicConv2d(64, 80, kernel_size=1)
        self.Conv2d_4a_3x3 = BasicConv2d(80, 192, kernel_size=3)

        # Inception blocks
        self.Mixed_5b = InceptionA(192, pool_features=32)
        self.Mixed_5c = InceptionA(256, pool_features=64)
        self.Mixed_5d = InceptionA(288, pool_features=64)
        self.Mixed_6a = InceptionB(288)
        self.Mixed_6b = InceptionC(768, channels_7x7=128)
        self.Mixed_6c = InceptionC(768, channels_7x7=160)
        self.Mixed_6d = InceptionC(768, channels_7x7=160)
        self.Mixed_6e = InceptionC(768, channels_7x7=192)

        if self.aux_logits:
            self.AuxLogits = InceptionAux(768, num_classes)

        self.Mixed_7a = InceptionD(768)
        self.Mixed_7b = InceptionE(1280)
        self.Mixed_7c = InceptionE(2048)
```

```python
        self.avgpool = nn.AdaptiveAvgPool2d((1, 1))
        self.fc = nn.Linear(2048, num_classes)

    def forward(self, x):
        x = self.Conv2d_1a_3x3(x)
        x = self.Conv2d_2a_3x3(x)
        x = self.Conv2d_2b_3x3(x)
        x = nn.functional.max_pool2d(x, kernel_size=3, stride=2)
        x = self.Conv2d_3b_1x1(x)
        x = self.Conv2d_4a_3x3(x)
        x = nn.functional.max_pool2d(x, kernel_size=3, stride=2)

        x = self.Mixed_5b(x)
        x = self.Mixed_5c(x)
        x = self.Mixed_5d(x)
        x = self.Mixed_6a(x)
        x = self.Mixed_6b(x)
        x = self.Mixed_6c(x)
        x = self.Mixed_6d(x)
        x = self.Mixed_6e(x)

        if self.training and self.aux_logits:
            aux = self.AuxLogits(x)

        x = self.Mixed_7a(x)
        x = self.Mixed_7b(x)
        x = self.Mixed_7c(x)

        x = self.avgpool(x)
        x = torch.flatten(x, 1)
        x = self.fc(x)

        if self.training and self.aux_logits:
            return x, aux
        return x


model = InceptionV3(num_classes=10, aux_logits=False, transform_input=False).
 ↪to(device)
```

```
ship  horse bird  horse
```

[6]:
```python
import torch.optim as optim

criterion = nn.CrossEntropyLoss()
```

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

[7]:
```
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)
```

[8]:
```
model_name = "GoogleNetV3_scartch"
# Training loop
num_epochs = 10
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: 1/10 | Train Loss: 2.0003 | Train Acc: 0.2567 | Valid Loss: 1.6489 |
Valid Acc: 0.4062
Epoch: 2/10 | Train Loss: 1.5463 | Train Acc: 0.4433 | Valid Loss: 1.2414 |
Valid Acc: 0.5602
Epoch: 3/10 | Train Loss: 1.2887 | Train Acc: 0.5431 | Valid Loss: 1.1126 |
Valid Acc: 0.6102
Epoch: 4/10 | Train Loss: 1.1223 | Train Acc: 0.6049 | Valid Loss: 1.0199 |
Valid Acc: 0.6435
```

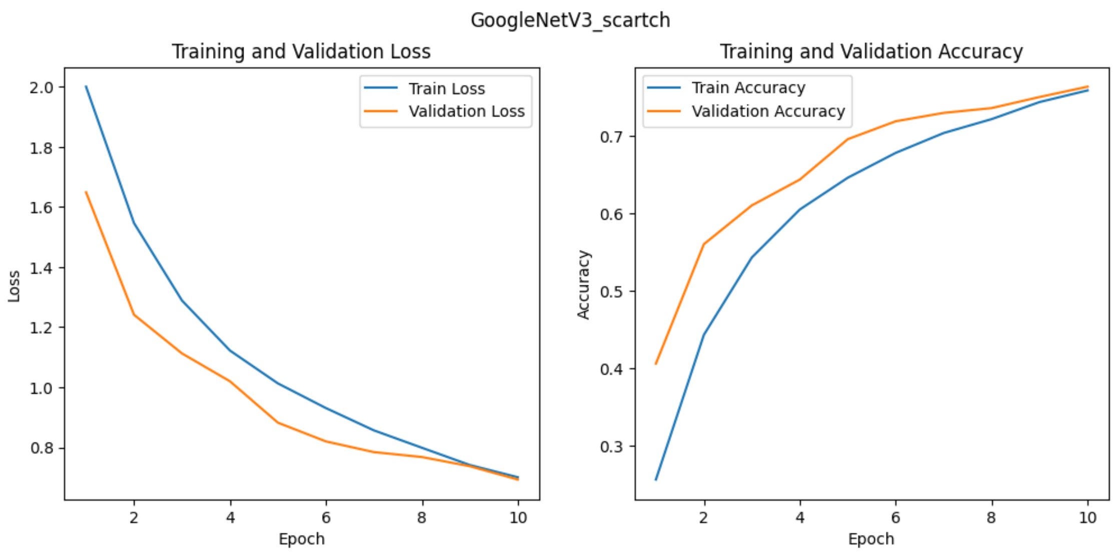
```
Epoch: 5/10 | Train Loss: 1.0129 | Train Acc: 0.6459 | Valid Loss: 0.8822 |
Valid Acc: 0.6956
Epoch: 6/10 | Train Loss: 0.9309 | Train Acc: 0.6780 | Valid Loss: 0.8199 |
Valid Acc: 0.7187
Epoch: 7/10 | Train Loss: 0.8567 | Train Acc: 0.7036 | Valid Loss: 0.7843 |
Valid Acc: 0.7295
Epoch: 8/10 | Train Loss: 0.7989 | Train Acc: 0.7215 | Valid Loss: 0.7680 |
Valid Acc: 0.7357
Epoch: 9/10 | Train Loss: 0.7414 | Train Acc: 0.7435 | Valid Loss: 0.7374 |
Valid Acc: 0.7500
Epoch: 10/10 | Train Loss: 0.7007 | Train Acc: 0.7585 | Valid Loss: 0.6930 |
Valid Acc: 0.7633
```

[9]:

```
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()
```



[11]:
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import numpy as np

loaded_model = InceptionV3(num_classes=10, aux_logits=False,␣
 ↪transform_input=False).to(device)
loaded_model.load_state_dict(torch.load('/content/GoogleNetV3_scartch.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)
```

```python
# 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()
```