TOURE-Boubacar-Projet

February 15, 2023

1 Projet - Deep Learning

Auteur : TOURE Boubacar (boubacar.toure@etud.univ-angers.fr), étudiant en Master 2 Informatique à la faculté des sciences d'Angers

Professeur Référent : Sylvain Lamprier (sylvain.lamprier@univ-angers.fr)

2 Import du projet

[ ]:
```
import torchvision.transforms as transforms
import matplotlib.pyplot as plt
import torch.nn as nn
import torchvision
import zipfile
import tarfile
import shutil
import torch
import time
import os

from tqdm import tqdm
from torchvision import models
from tqdm.autonotebook import tqdm
from torch.utils.tensorboard import SummaryWriter

from torchvision.models import ResNet18_Weights
from torchvision.models import AlexNet_Weights
from torchvision.models import SqueezeNet1_0_Weights
from torchvision.models import VGG16_Weights
from torchvision.models import DenseNet161_Weights
from torchvision.models import Inception_V3_Weights

# --->  A DECOMMENTER LES INSTRUCTIONS CI-DESSOUS SUR GOOGLE COLAB  <---
# Installez wget, Pillow, PIL, image avec pip
!pip install wget
!pip install Pillow==7.2.0
!pip install image
```

```
from PIL import Image

# Importation de la bibliothèque wget
import wget
```

3 Déclaration des fonctions

[8]:
```
def train(model, train_loader, validation_loader, loss_fn, optimizer, epochs=8,␣
↪typeTrain=""):
    device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
    print("Device is :", device)

    model = model.to(device)
    loss_fn = loss_fn.to(device)

    # Clear any logs from previous runs
    if os.path.exists(f"/tmp/logs/project-train"):
        shutil.rmtree(f"/tmp/logs/project-train")

    # On créé un writer avec la date du modèle pour s'y retrouver
    TB_PATH = f"/tmp/logs/project"

    summary = SummaryWriter(f"{TB_PATH}-{typeTrain}-train")

    train_losses = []
    validation_losses = []
    accuraciesOfValidation = []
    accuraciesOfTrain = []

    start_time = time.time()
    print('\n', '-' * 40)
    for epoch in range(1, epochs+1):
        # Entraînement sur les données d'entraînement
        model.train()
        train_loss = 0.0
        correct = 0.0
        total = 0.0

        for images, labels in train_loader:
            images, labels = images.to(device), labels.to(device)
            optimizer.zero_grad()
            # Inception_v3 specific code
            if typeTrain == "inception_v3":
                outputs, aux_outputs = model(images)
                loss = loss_fn(outputs, labels) + 0.3 * loss_fn(aux_outputs,␣
↪labels)
```

```
            else:
                outputs = model(images)
                loss = loss_fn(outputs, labels)
            _, predicted = torch.max(outputs, 1)
            loss.backward()
            optimizer.step()
            train_loss += loss.item()
            total += labels.size(0)
            correct += (predicted == labels).sum().item()

        train_accuracy = correct / total
        accuraciesOfTrain.append(train_accuracy)
        summary.add_scalar("Accuracy_Of_Train", train_accuracy, epoch)
        summary.add_scalar("Loss_Of_Train", train_loss/len(train_loader), epoch)
        train_losses.append(train_loss/len(train_loader))

        if epoch % 2 == 0:
            # Evaluation sur les données de test
            model.eval()
            with torch.no_grad():
                validation_loss = 0.0
                correct = 0.0
                total = 0.0
                for images, labels in validation_loader:
                    images, labels = images.to(device), labels.to(device)
                    # Inception_v3 specific code
                    if typeTrain == "inception_v3":
                        outputs, aux_outputs = model(images)
                        validation_loss += loss_fn(outputs, labels).item() + 0.
↪3 * loss_fn(aux_outputs, labels).item()
                    else:
                        outputs = model(images)
                        validation_loss += loss_fn(outputs, labels).item()
                    _, predicted = torch.max(outputs, 1)
                    total += labels.size(0)
                    correct += (predicted == labels).sum().item()

                print('\t', '-' * 40)
                print("\tPredicted :", predicted)
                print("\tResult :", labels)
                print("\tTOTAL (correct/total):", correct, '/', total)
                print('\t', '-' * 40)

                validation_loss = validation_loss/len(validation_loader)
                validation_accuracy = correct / total
                accuraciesOfValidation.append(validation_accuracy)
```

```
                summary.add_scalar("Accuracy_Of_Validation",␣
↪validation_accuracy, epoch)
                summary.add_scalar("Loss_Of_Validation", validation_loss/
↪len(validation_loader), epoch)
                validation_losses.append(validation_loss/len(validation_loader))

                print("\tEpoch {}, Validation Loss: {:.4f}, Validation Accuracy:
↪ {:.4f} %".format(epoch, validation_loss, validation_accuracy * 100.0, '\n'))
        else:
            print("Epoch {}, Train Loss: {:.4f}, Train Accuracy: {:.4f} %".
↪format(epoch, train_loss/len(train_loader), train_accuracy * 100.0))
    print('\n', '-' * 40)
    end_time = time.time()

    trainTime = end_time - start_time
    trainModelComplexity = sum(p.numel() for p in model.parameters() if p.
↪requires_grad)

    plt.figure(figsize=(20, 8))
    plt.subplot(121)
    plt.plot(train_losses)
    plt.title('Train Loss')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.grid()

    plt.subplot(122)
    plt.plot(accuraciesOfTrain)
    plt.title('Train Accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.grid()
    plt.show()

    plt.figure(figsize=(20, 8))
    plt.subplot(121)
    plt.plot(validation_losses)
    plt.title('Validation Loss')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.grid()

    plt.subplot(122)
    plt.plot(accuraciesOfValidation)
    plt.title('Validation Accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
```

```
    plt.grid()
    plt.show()

    # Load the TensorBoard notebook extension
    %load_ext tensorboard
    %tensorboard --logdir {TB_PATH}-{typeTrain}-train

    return trainTime, trainModelComplexity, validation_loss,␣
↪validation_accuracy, accuraciesOfValidation

def prepare_data(mean, std, size_of_image, transform, batch_size, split):
    # Chargement des données dans le dossier 101_ObjectCategories
    dataset = torchvision.datasets.ImageFolder(root='./101_ObjectCategories',␣
↪transform=transform)

    # Chargement des données dans le dossier 101_ObjectCategories
    dataset = torchvision.datasets.ImageFolder(root='./101_ObjectCategories',␣
↪transform=transform)

    # # Découpe des données en ensembles d'apprentissage et de test avec 90 %␣
↪d'entrainement et 10 % de test de validation
    # train_size = int(split * len(dataset))
    # test_size = len(dataset) - train_size
    # train_dataset, test_dataset = torch.utils.data.random_split(dataset,␣
↪[train_size, test_size])

    # Usage de Subset pour la formation des données d'entrainement et de tests␣
↪de validations
    indices = list(range(len(dataset)))
    split = int(split * len(dataset))
    train_indices = indices[:split]
    test_indices = indices[split:]
    train_dataset = torch.utils.data.Subset(dataset, train_indices)
    test_dataset = torch.utils.data.Subset(dataset, test_indices)

    # Création des dataloaders pour les données d'entrainement et de tests de␣
↪validations (via torch)
    train_dataloader = torch.utils.data.DataLoader(train_dataset,␣
↪batch_size=batch_size, shuffle=True, pin_memory=True)
    test_dataloader = torch.utils.data.DataLoader(test_dataset,␣
↪batch_size=batch_size, shuffle=True, pin_memory=True)

    return train_dataloader, test_dataloader

def prepare_data_on_google_colab(mean, std, size_of_image, transform,␣
↪batch_size, split):
```

```
    # Téléchargez l'archive
    if not os.path.exists("caltech-101.zip"):
        url = "https://data.caltech.edu/records/mzrjq-6wc02/files/caltech-101.
↪zip"
        wget.download(url)

    # Retirez le répertoire "101_ObjectCategories"
    if os.path.exists("101_ObjectCategories"):
        shutil.rmtree("101_ObjectCategories")

    with zipfile.ZipFile('caltech-101.zip', 'r') as zip_ref:
        zip_ref.extractall()

    with tarfile.open('caltech-101/101_ObjectCategories.tar.gz', "r:gz") as tar:
        tar.extractall()

    # Retirez le répertoire "caltech-101"
    if os.path.exists("caltech-101"):
        shutil.rmtree("caltech-101")

    # Retirez le répertoire "BACKGROUND_Google"
    if os.path.exists("101_ObjectCategories/BACKGROUND_Google"):
        shutil.rmtree("101_ObjectCategories/BACKGROUND_Google")

    print("La liste des fichiers du dossier '/content/' sur colab :", os.
↪listdir())

    # Chargement des données dans le dossier 101_ObjectCategories
    dataset = torchvision.datasets.ImageFolder(root='./101_ObjectCategories',␣
↪transform=transform)

    # Découpe des données en ensembles d'apprentissage et de test avec 90 %␣
↪d'entrainement et 10 % de test de validation
    train_size = int(split * len(dataset))
    test_size = len(dataset) - train_size
    train_dataset, test_dataset = torch.utils.data.random_split(dataset,␣
↪[train_size, test_size])

    # # Usage de Subset pour la formation des données d'entrainement et de␣
↪tests de validations
    # indices = list(range(len(dataset)))
    # split = int(split * len(dataset))
    # train_indices = indices[:split]
    # test_indices = indices[split:]
    # train_dataset = torch.utils.data.Subset(dataset, train_indices)
    # test_dataset = torch.utils.data.Subset(dataset, test_indices)
```

```
    # Création des dataloaders pour les données d'entrainement et de tests de␣
 ↪validations (via torch)
    train_dataloader = torch.utils.data.DataLoader(train_dataset,␣
 ↪batch_size=batch_size, shuffle=True, pin_memory=True)
    test_dataloader = torch.utils.data.DataLoader(test_dataset,␣
 ↪batch_size=batch_size, shuffle=True, pin_memory=True)

    return train_dataloader, test_dataloader

def adapt_pretrained_model(model_name, num_classes=101):
    # Load the pretrained model
    if model_name == "resnet18":
        model = models.resnet18(weights=ResNet18_Weights.IMAGENET1K_V1)
        model.fc = torch.nn.Linear(model.fc.in_features, num_classes)
    elif model_name == "alexnet":
        model = models.alexnet(weights=AlexNet_Weights.IMAGENET1K_V1)
        model.classifier[-1] = torch.nn.Linear(model.classifier[-1].
 ↪in_features, num_classes)
    elif model_name == "squeezenet1_0":
        model = models.squeezenet1_0(weights=SqueezeNet1_0_Weights.
 ↪IMAGENET1K_V1)
        model.classifier[1] = torch.nn.Conv2d(512, num_classes, kernel_size=(1,␣
 ↪1), stride=(1, 1))
        model.num_classes = num_classes
    elif model_name == "vgg16":
        model = models.vgg16(weights=VGG16_Weights.IMAGENET1K_V1)
        model.classifier[-1] = torch.nn.Linear(model.classifier[-1].
 ↪in_features, num_classes)
    elif model_name == "densenet161":
        model = models.densenet161(weights=DenseNet161_Weights.IMAGENET1K_V1)
        model.classifier = torch.nn.Linear(in_features=2208,␣
 ↪out_features=num_classes, bias=True)
        model.num_classes = num_classes
    elif model_name == "inception_v3":
        model = models.inception_v3(weights=Inception_V3_Weights.IMAGENET1K_V1)
        model.fc = torch.nn.Linear(model.fc.in_features, num_classes)
    else:
        raise ValueError("Model not recognized")

    # freeze all model parameters
    for param in model.parameters():
        param.requiresGrad = False

    return model
```

```
def compare_models(executionTimeOfModel1, complexityOfModel1,␣
 ↪validationLossOfModel1, accuracyOfModel1, executionTimeOfModel2,␣
 ↪complexityOfModel2, validationLossOfModel2, accuracyOfModel2):
    print("Le modèle 1 a une perte de {} sur les données de validation avec une␣
 ↪précision de {}% et une complexité de {} paramètres et un temps d'évaluation␣
 ↪de {}s".format(validationLossOfModel1, accuracyOfModel1*100.0,␣
 ↪complexityOfModel1, executionTimeOfModel1))
    print("\nLe modèle 2 a une perte de {} sur les données de validation avec␣
 ↪une précision de {}% et une complexité de {} paramètres et un temps␣
 ↪d'évaluation de {}s".format(validationLossOfModel2, accuracyOfModel2*100.0,␣
 ↪complexityOfModel2, executionTimeOfModel2))

    if validationLossOfModel1 < validationLossOfModel2:
        print("\n\tLe modèle 1 a une perte plus faible sur les données de␣
 ↪validation.")
        return 1
    else:
        print("\n\tLe modèle 2 a une perte plus faible sur les données de␣
 ↪validation.")
        return 2

def affiche_dataloader(dataloader):
    for i, data in enumerate(dataloader):
        if i <= 10:
            images, labels = data
            print("Image Shape: ", images.shape)
            print("Label Shape: ", labels.shape)
        else:
            break
```

4 Chargement des données du projet

[9]:
```
mean = [0.485, 0.456, 0.406]
std = [0.229, 0.224, 0.225]
size_of_image = [224, 224]

batch_size = 16
split = 0.9
epochs = 8

transform = transforms.Compose([
    transforms.Resize(size_of_image),
    transforms.CenterCrop(size_of_image),
    transforms.ToTensor(),
    transforms.Normalize(mean, std)
])
```

```
# train_dataloader, test_dataloader = prepare_data(mean, std, size_of_image,␣
 ↪transform, batch_size, split)
train_dataloader, test_dataloader = prepare_data_on_google_colab(mean, std,␣
 ↪size_of_image, transform, batch_size, split)
```

```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
```

5 Entrainement et chargement des modèles

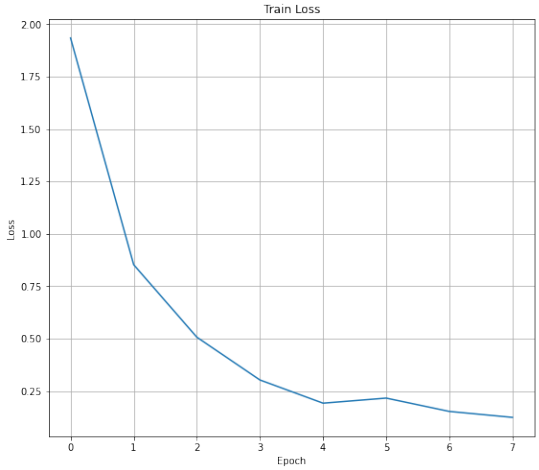
5.1 Test sur les jeux de données en utilisant le séparateur « torch.utils.data.Subset »

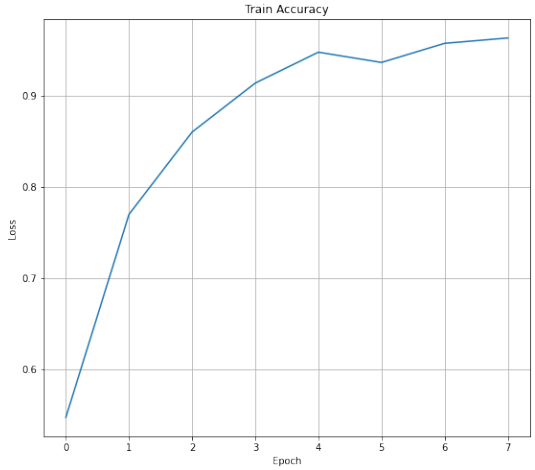
5.1.1 Le modèle « resnet18 » avec l'optimiseur : Adam

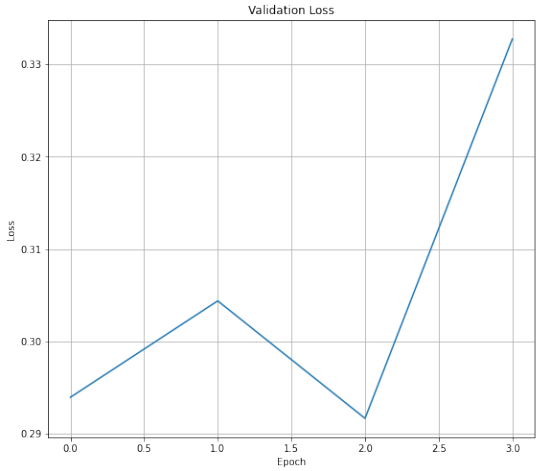
[ ]:
```
modelAdam_resnet18 = adapt_pretrained_model("resnet18")
loss_fn = nn.CrossEntropyLoss()
optimiseurAdam_resnet18 = torch.optim.Adam(modelAdam_resnet18.parameters(),␣
 ↪lr=0.001)
modelAdam_resnet18_trainTime, modelAdam_resnet18_trainModelComplexity,␣
 ↪modelAdam_resnet18_validation_loss, modelAdam_resnet18_accuracy, _ =␣
 ↪train(modelAdam_resnet18, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseurAdam_resnet18, epochs, typeTrain="resnet18-Adam")
```

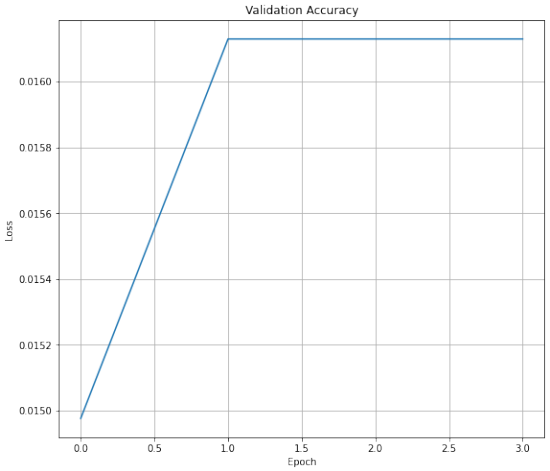
```
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.9346, Train Accuracy: 54.7061 %
         ----------------------------------------
        Predicted : tensor([69, 70,  1,  2], device='cuda:0')
        Result : tensor([92, 94, 94, 97], device='cuda:0')
        TOTAL (correct/total): 13.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 16.1665, Validation Accuracy: 1.4977 %
Epoch 3, Train Loss: 0.5070, Train Accuracy: 86.0417 %
         ----------------------------------------
        Predicted : tensor([84, 17, 82, 21], device='cuda:0')
        Result : tensor([100,  94,  90,  92], device='cuda:0')
        TOTAL (correct/total): 14.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 16.7408, Validation Accuracy: 1.6129 %
Epoch 5, Train Loss: 0.1921, Train Accuracy: 94.8137 %
         ----------------------------------------
        Predicted : tensor([56, 18, 23, 12], device='cuda:0')
        Result : tensor([93, 94, 94, 95], device='cuda:0')
        TOTAL (correct/total): 14.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 16.0407, Validation Accuracy: 1.6129 %
Epoch 7, Train Loss: 0.1526, Train Accuracy: 95.7869 %
         ---------------------------------------
        Predicted : tensor([35, 22, 49, 88], device='cuda:0')
        Result : tensor([94, 98, 92, 94], device='cuda:0')
        TOTAL (correct/total): 14.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 18.3013, Validation Accuracy: 1.6129 %

 ----------------------------------------
```









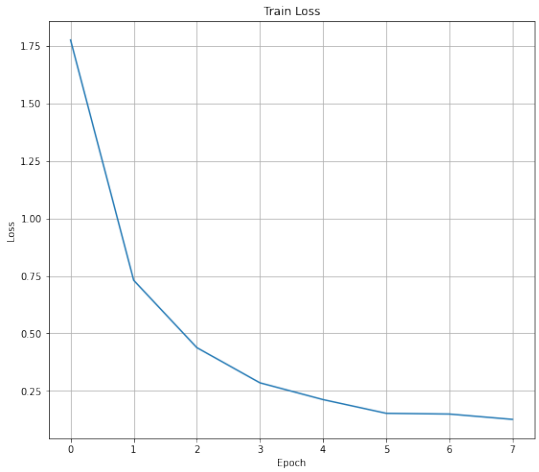

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

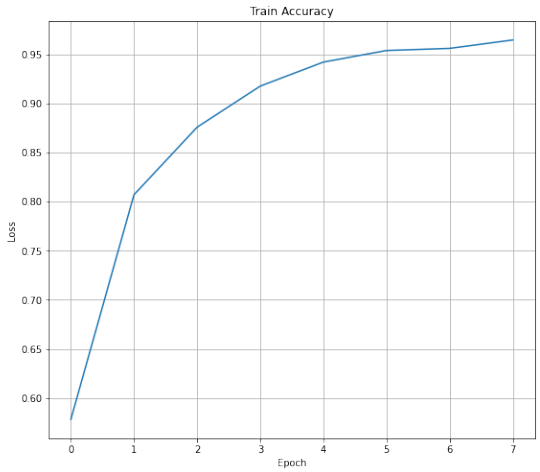
```
<IPython.core.display.Javascript object>
```

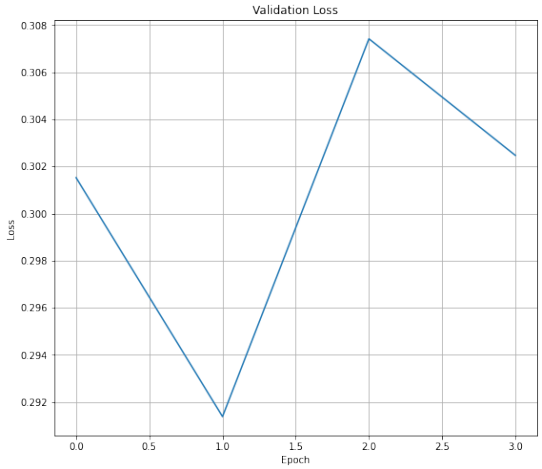
5.1.2 Le modèle « resnet18 » avec l'optimiseur : SGD

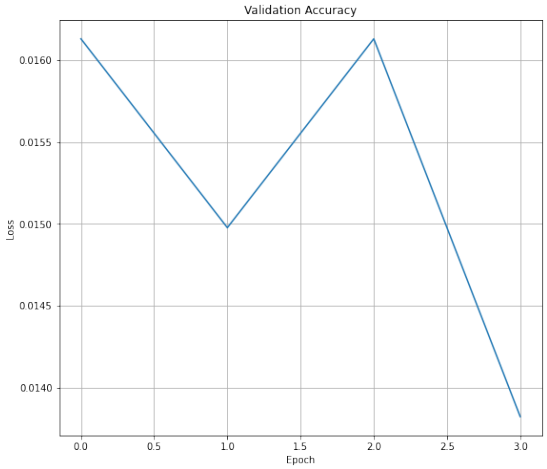
```
[ ]: modelSGD_resnet18 = adapt_pretrained_model("resnet18")
loss_fn = nn.CrossEntropyLoss()
optimiseurSGD_resnet18 = torch.optim.Adam(modelSGD_resnet18.parameters(), lr=0.
 ↪001)
modelSGD_resnet18_trainTime, modelSGD_resnet18_trainModelComplexity,␣
 ↪modelSGD_resnet18_validation_loss, modelSGD_resnet18_accuracy, _ =␣
 ↪train(modelSGD_resnet18, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseurSGD_resnet18, epochs, typeTrain="resnet18-SGD")
```

```
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.7773, Train Accuracy: 57.8179 %
         ----------------------------------------
        Predicted : tensor([16, 60, 65, 47], device='cuda:0')
        Result : tensor([96, 95, 92, 95], device='cuda:0')
        TOTAL (correct/total): 14.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 16.5837, Validation Accuracy: 1.6129 %
Epoch 3, Train Loss: 0.4382, Train Accuracy: 87.5784 %
         ----------------------------------------
        Predicted : tensor([63, 72, 39, 60], device='cuda:0')
        Result : tensor([94, 89, 91, 95], device='cuda:0')
        TOTAL (correct/total): 13.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 16.0259, Validation Accuracy: 1.4977 %
Epoch 5, Train Loss: 0.2120, Train Accuracy: 94.2118 %
         ----------------------------------------
        Predicted : tensor([72, 61, 61, 23], device='cuda:0')
        Result : tensor([94, 99, 99, 96], device='cuda:0')
        TOTAL (correct/total): 14.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 16.9079, Validation Accuracy: 1.6129 %
Epoch 7, Train Loss: 0.1491, Train Accuracy: 95.6076 %
         ----------------------------------------
        Predicted : tensor([56, 18, 13, 72], device='cuda:0')
        Result : tensor([98, 94, 94, 94], device='cuda:0')
        TOTAL (correct/total): 12.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 16.6357, Validation Accuracy: 1.3825 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
<IPython.core.display.Javascript object>
```

5.1.3 Comparaison : resnet18Adam VS resnet18SGD

[ ]:
```
resultTest1 = compare_models(modelAdam_resnet18_trainTime,␣
  ↪modelAdam_resnet18_trainModelComplexity, modelAdam_resnet18_validation_loss,␣
  ↪modelAdam_resnet18_accuracy, modelSGD_resnet18_trainTime,␣
  ↪modelSGD_resnet18_trainModelComplexity, modelSGD_resnet18_validation_loss,␣
  ↪modelSGD_resnet18_accuracy)

if resultTest1 == 1:
```

```
    print("\n_____________________________________________________\nLe Modèle␣
 ↪resnet18 avec Adam est le plus performant !
 ↪\n_____________________________________________________\n")
else:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪resnet18 avec SGD est le plus performant !
 ↪\n_____________________________________________________\n")
```

```
Le modèle 1 a une perte de 18.301277299360795 sur les données de validation avec
une précision de 1.6129032258064515% et une complexité de 11228325 paramètres et
un temps d'évaluation de 428.42567563056946s

Le modèle 2 a une perte de 16.63567485809326 sur les données de validation avec
une précision de 1.3824884792626728% et une complexité de 11228325 paramètres et
un temps d'évaluation de 448.3988983631134s

        Le modèle 2 a une perte plus faible sur les données de validation.


-----------------------------------------------------
Le Modèle resnet18 avec SGD est le plus performant !
-----------------------------------------------------
```

5.1.4 Conclusion :

A la suite de nombreux tests que nous avons eu à réaliser en utilisant **"torch.utils.data.Subset"**. Nous pouvons conclure que lors des séances d'entrainement de nos modèles, nous avons de très bon résultats. Par contre, lorsque nous passons à la phase de validation. Nous remarquons que nous obtenons de très mauvaises prédictions des données de sorties (Avoir sur l'image ci-dessus). D'où l'obtention d'un faible pourcentage d'accuracy (1.6129 % et 1.3825 %) pour le modèles resnet18 utilisant respectivement l'optimiseur Adam et SGD.

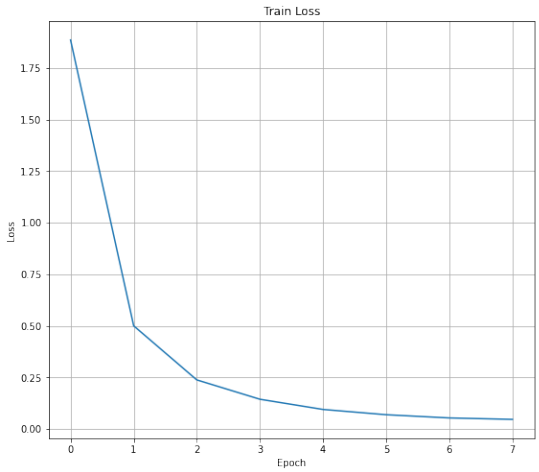
De plus, nous pouvons remarquer que l'usage de l'optimiseur SGD est le plus adapté pour la réalisation de nos tests. Voilà pourquoi, pour tous les tests que nous allons faire à partir de maintenant. **L'optimiseur SGD sera prioritaire**.

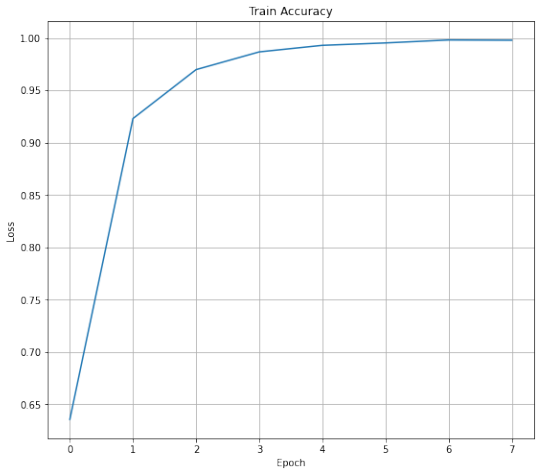
5.2 Test sur les jeux de données en utilisant le séparateur « torch.utils.data.random_split »

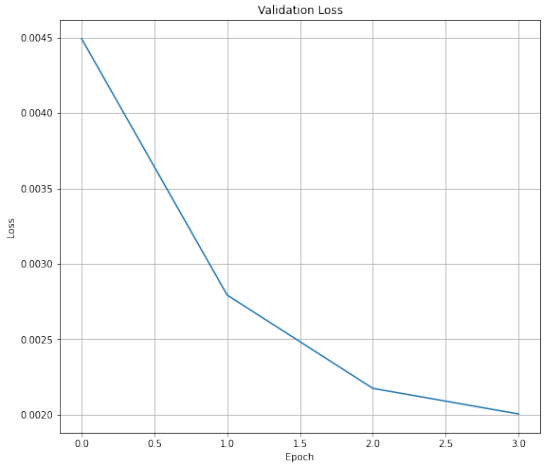
5.2.1 Le modèle « resnet18 » avec l'optimiseur : SGD

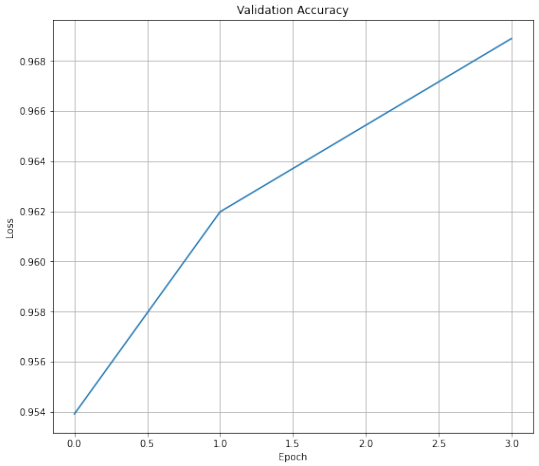
[ ]:
```
model_resnet18 = adapt_pretrained_model("resnet18")
loss_fn = nn.CrossEntropyLoss()
optimiseur_resnet18 = torch.optim.SGD(model_resnet18.parameters(), lr=0.001,␣
 ↪momentum=0.9)
model_resnet18_trainTime, model_resnet18_trainModelComplexity,␣
 ↪model_resnet18_validation_loss, model_resnet18_accuracy, _ =␣
 ↪train(model_resnet18, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseur_resnet18, epochs, typeTrain="resnet18")
```

```
Downloading: "https://download.pytorch.org/models/resnet18-f37072fd.pth" to
/root/.cache/torch/hub/checkpoints/resnet18-f37072fd.pth

  0%|          | 0.00/44.7M [00:00<?, ?B/s]

Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.8867, Train Accuracy: 63.5677 %
         ----------------------------------------
        Predicted : tensor([32, 20,  1, 12], device='cuda:0')
        Result : tensor([32, 20,  1, 12], device='cuda:0')
        TOTAL (correct/total): 828.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.2472, Validation Accuracy: 95.3917 %
Epoch 3, Train Loss: 0.2380, Train Accuracy: 96.9778 %
         ----------------------------------------
        Predicted : tensor([ 0, 68, 90, 55], device='cuda:0')
        Result : tensor([ 0, 68, 90, 55], device='cuda:0')
        TOTAL (correct/total): 835.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1536, Validation Accuracy: 96.1982 %
Epoch 5, Train Loss: 0.0947, Train Accuracy: 99.2957 %
         ----------------------------------------
        Predicted : tensor([22, 16, 12, 56], device='cuda:0')
        Result : tensor([22, 16, 12, 56], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1196, Validation Accuracy: 96.5438 %
Epoch 7, Train Loss: 0.0536, Train Accuracy: 99.8079 %
         ----------------------------------------
        Predicted : tensor([13, 88, 69, 18], device='cuda:0')
        Result : tensor([13, 88, 69, 18], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1103, Validation Accuracy: 96.8894 %

 ----------------------------------------
```









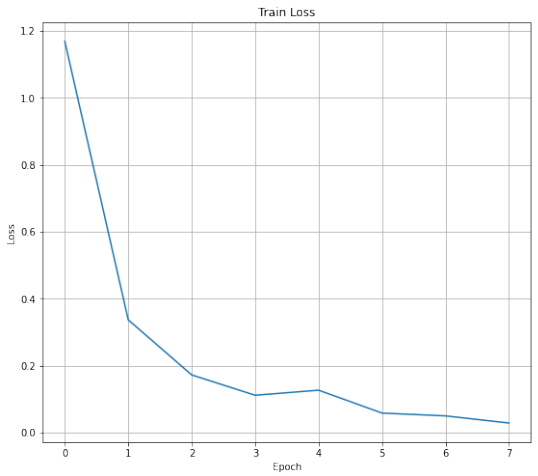

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

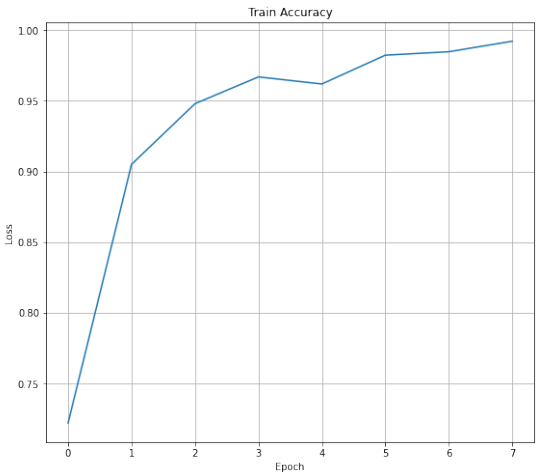
```
<IPython.core.display.Javascript object>
```

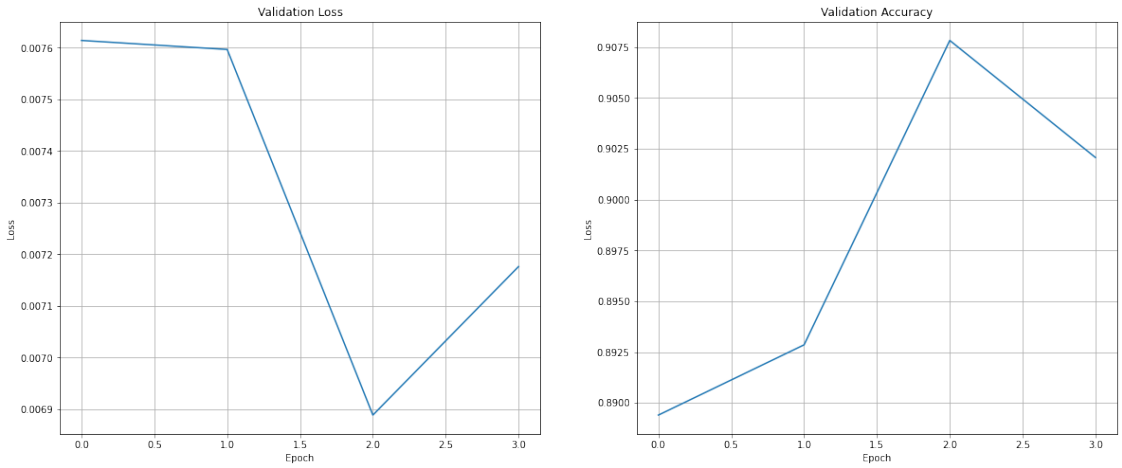
5.2.2 Le modèle « alexnet » avec l'optimiseur : SGD

[ ]:
```
model_alexnet = adapt_pretrained_model("alexnet")
loss_fn = nn.CrossEntropyLoss()
optimiseur_alexnet = torch.optim.SGD(model_alexnet.parameters(), lr=0.001,␣
 ↪momentum=0.9)
model_alexnet_trainTime, model_alexnet_trainModelComplexity,␣
 ↪model_alexnet_validation_loss, model_alexnet_accuracy, _ =␣
 ↪train(model_alexnet, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseur_alexnet, epochs, typeTrain="alexnet")
```

```
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.1689, Train Accuracy: 72.2244 %
         ----------------------------------------
        Predicted : tensor([29,  5, 19, 23], device='cuda:0')
        Result : tensor([29,  5, 19, 23], device='cuda:0')
        TOTAL (correct/total): 772.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4188, Validation Accuracy: 88.9401 %
Epoch 3, Train Loss: 0.1729, Train Accuracy: 94.8009 %
         ----------------------------------------
        Predicted : tensor([ 5, 57, 23,  0], device='cuda:0')
        Result : tensor([ 5, 57, 23,  0], device='cuda:0')
        TOTAL (correct/total): 775.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4178, Validation Accuracy: 89.2857 %
Epoch 5, Train Loss: 0.1273, Train Accuracy: 96.1967 %
         ----------------------------------------
        Predicted : tensor([40, 40, 75, 93], device='cuda:0')
        Result : tensor([40, 40, 75, 93], device='cuda:0')
        TOTAL (correct/total): 788.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.3789, Validation Accuracy: 90.7834 %
Epoch 7, Train Loss: 0.0506, Train Accuracy: 98.4761 %
         ----------------------------------------
        Predicted : tensor([94, 67, 23,  0], device='cuda:0')
        Result : tensor([94, 86, 23,  0], device='cuda:0')
        TOTAL (correct/total): 783.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.3947, Validation Accuracy: 90.2074 %

 ----------------------------------------
```








```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
Reusing TensorBoard on port 6010 (pid 35388), started 0:13:47 ago. (Use '!kill␣
 ↪35388' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

5.2.3 Le modèle « squeezenet1_0 » avec l'optimiseur : SGD

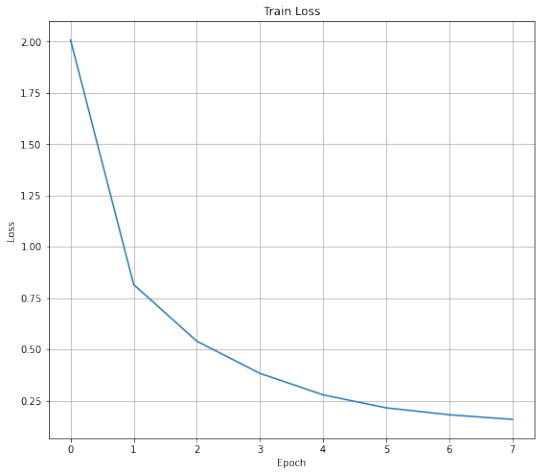
```
[ ]: model_squeezenet1_0 = adapt_pretrained_model("squeezenet1_0")
loss_fn = nn.CrossEntropyLoss()
optimiseur_squeezenet1_0 = torch.optim.SGD(model_squeezenet1_0.parameters(),␣
 ↪lr=0.001, momentum=0.9)
model_squeezenet1_0_trainTime, model_squeezenet1_0_trainModelComplexity,␣
 ↪model_squeezenet1_0_validation_loss, model_squeezenet1_0_accuracy, _ =␣
 ↪train(model_squeezenet1_0, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseur_squeezenet1_0, epochs, typeTrain="squeezenet1_0")
```

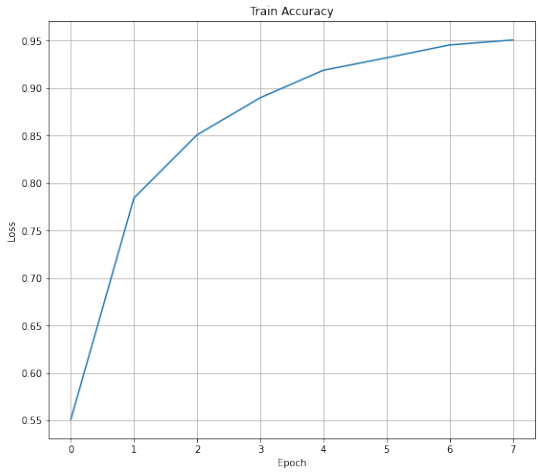
```
Downloading: "https://download.pytorch.org/models/squeezenet1_0-b66bff10.pth" to
/root/.cache/torch/hub/checkpoints/squeezenet1_0-b66bff10.pth
```

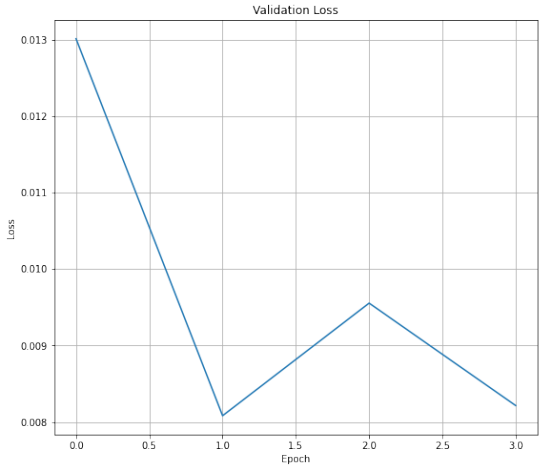
```
  0%|          | 0.00/4.78M [00:00<?, ?B/s]
```

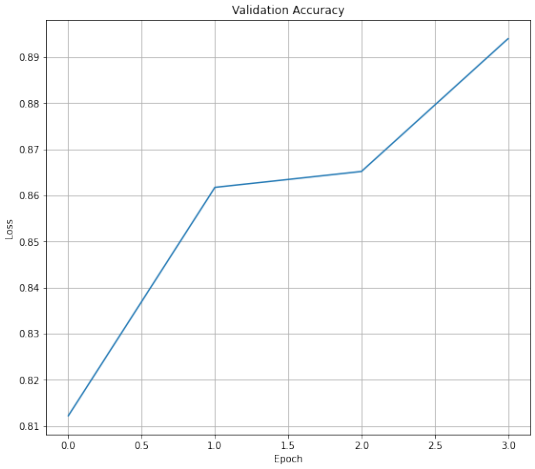
```
Device is : cuda:0

 ---------------------------------------
Epoch 1, Train Loss: 2.0085, Train Accuracy: 55.1159 %
         ---------------------------------------
        Predicted : tensor([73, 81,  5, 75], device='cuda:0')
        Result : tensor([73, 81,  5, 75], device='cuda:0')
```

```
        TOTAL (correct/total): 705.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.7157, Validation Accuracy: 81.2212 %
Epoch 3, Train Loss: 0.5398, Train Accuracy: 85.0813 %
         ----------------------------------------
        Predicted : tensor([94, 92,  3, 63], device='cuda:0')
        Result : tensor([94, 92,  3, 63], device='cuda:0')
        TOTAL (correct/total): 748.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4445, Validation Accuracy: 86.1751 %
Epoch 5, Train Loss: 0.2783, Train Accuracy: 91.8812 %
         ----------------------------------------
        Predicted : tensor([19, 24, 29, 48], device='cuda:0')
        Result : tensor([19, 24, 29, 48], device='cuda:0')
        TOTAL (correct/total): 751.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.5255, Validation Accuracy: 86.5207 %
Epoch 7, Train Loss: 0.1810, Train Accuracy: 94.5448 %
         ----------------------------------------
        Predicted : tensor([56, 58,  1,  3], device='cuda:0')
        Result : tensor([56, 54,  1,  3], device='cuda:0')
        TOTAL (correct/total): 776.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4518, Validation Accuracy: 89.4009 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

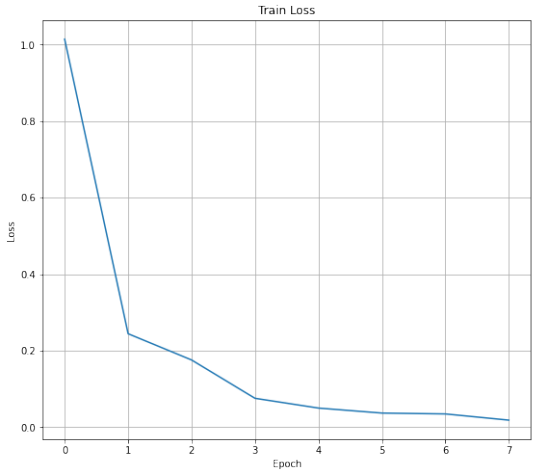
```
<IPython.core.display.Javascript object>
```

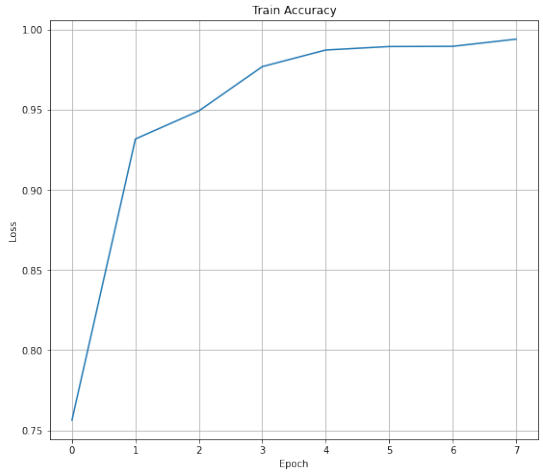
5.2.4 Le modèle « vgg16 » avec l'optimiseur : SGD

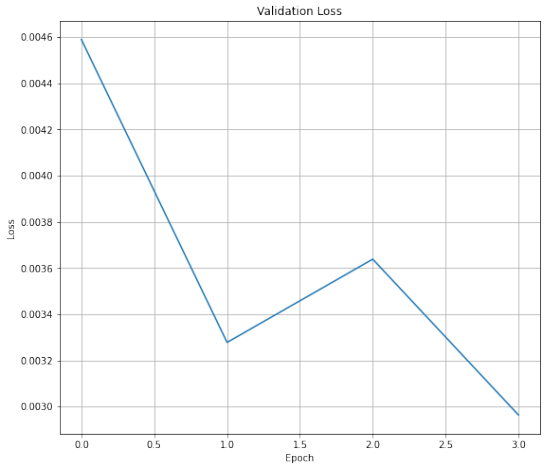
[ ]:
```
model_vgg16 = adapt_pretrained_model("vgg16")
loss_fn = nn.CrossEntropyLoss()
optimiseur_vgg16 = torch.optim.SGD(model_vgg16.parameters(), lr=0.001,␣
 ↪momentum=0.9)
model_vgg16_trainTime, model_vgg16_trainModelComplexity,␣
 ↪model_vgg16_validation_loss, model_vgg16_accuracy, _ = train(model_vgg16,␣
 ↪train_dataloader, test_dataloader, loss_fn, optimiseur_vgg16, epochs,␣
 ↪typeTrain="vgg16")
```

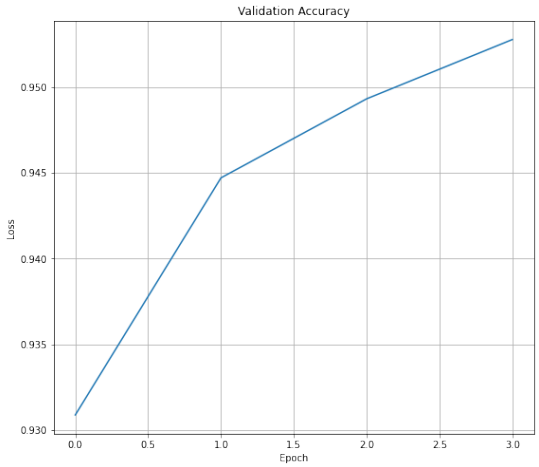
```
Downloading: "https://download.pytorch.org/models/vgg16-397923af.pth" to
/root/.cache/torch/hub/checkpoints/vgg16-397923af.pth

  0%|          | 0.00/528M [00:00<?, ?B/s]

Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.0139, Train Accuracy: 75.6307 %
         ----------------------------------------
        Predicted : tensor([64,  0, 63, 46], device='cuda:0')
        Result : tensor([64,  0, 63, 46], device='cuda:0')
        TOTAL (correct/total): 808.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.2524, Validation Accuracy: 93.0876 %
Epoch 3, Train Loss: 0.1759, Train Accuracy: 94.9417 %
         ----------------------------------------
```

```
        Predicted : tensor([81,  3,  3, 73], device='cuda:0')
        Result : tensor([81,  3,  3, 73], device='cuda:0')
        TOTAL (correct/total): 820.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1803, Validation Accuracy: 94.4700 %
Epoch 5, Train Loss: 0.0502, Train Accuracy: 98.7450 %
         ----------------------------------------
        Predicted : tensor([12, 18, 18, 57], device='cuda:0')
        Result : tensor([12, 18, 18, 57], device='cuda:0')
        TOTAL (correct/total): 824.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.2001, Validation Accuracy: 94.9309 %
Epoch 7, Train Loss: 0.0349, Train Accuracy: 98.9755 %
         ----------------------------------------
        Predicted : tensor([ 5, 93, 36, 62], device='cuda:0')
        Result : tensor([ 5, 93, 36, 62], device='cuda:0')
        TOTAL (correct/total): 827.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1630, Validation Accuracy: 95.2765 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

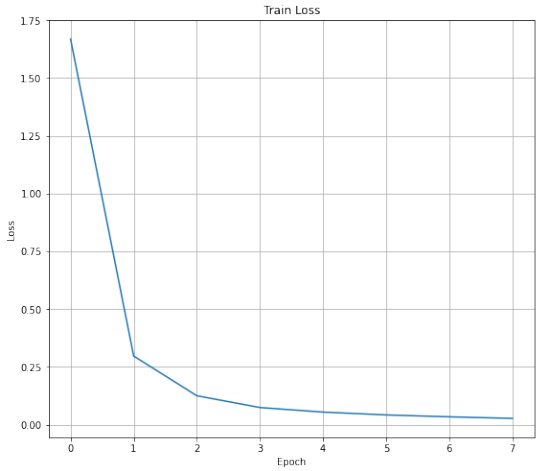
```
<IPython.core.display.Javascript object>
```

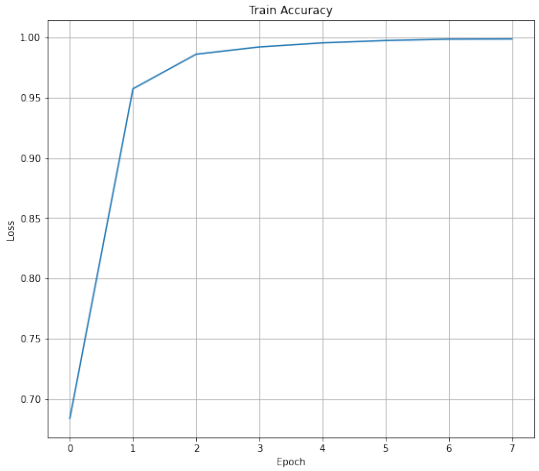
5.2.5 Le modèle « densenet161 » avec l'optimiseur : SGD

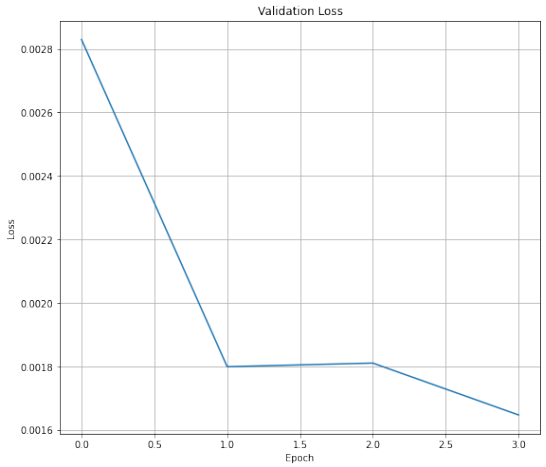
```
[ ]: model_densenet161 = adapt_pretrained_model("densenet161")
loss_fn = nn.CrossEntropyLoss()
optimiseur_densenet161 = torch.optim.SGD(model_densenet161.parameters(), lr=0.
  ↪001, momentum=0.9)
model_densenet161_trainTime, model_densenet161_trainModelComplexity,␣
  ↪model_densenet161_validation_loss, model_densenet161_accuracy, _ =␣
  ↪train(model_densenet161, train_dataloader, test_dataloader, loss_fn,␣
  ↪optimiseur_densenet161, epochs, typeTrain="densenet161")
```

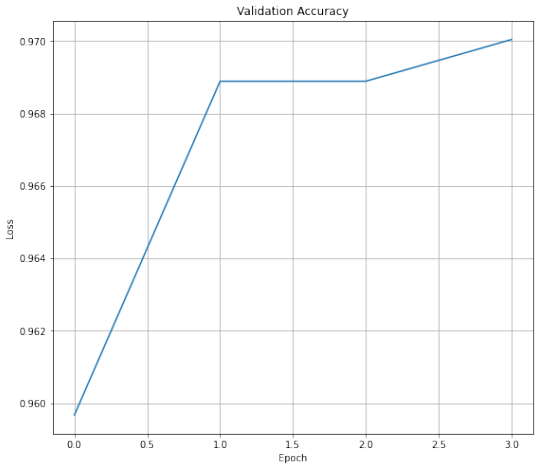
```
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.6695, Train Accuracy: 68.3698 %
         ----------------------------------------
        Predicted : tensor([ 3,  0, 51, 75], device='cuda:0')
        Result : tensor([ 3,  0, 51, 18], device='cuda:0')
        TOTAL (correct/total): 833.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1556, Validation Accuracy: 95.9677 %
Epoch 3, Train Loss: 0.1256, Train Accuracy: 98.6042 %
         ----------------------------------------
        Predicted : tensor([22, 40, 23, 47], device='cuda:0')
        Result : tensor([22, 40, 23, 47], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
```

```
        Epoch 4, Validation Loss: 0.0990, Validation Accuracy: 96.8894 %
Epoch 5, Train Loss: 0.0546, Train Accuracy: 99.5518 %
         ---------------------------------------
        Predicted : tensor([94,  3, 86, 74], device='cuda:0')
        Result : tensor([94,  3, 86, 74], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ---------------------------------------
        Epoch 6, Validation Loss: 0.0996, Validation Accuracy: 96.8894 %
Epoch 7, Train Loss: 0.0342, Train Accuracy: 99.8591 %
         ---------------------------------------
        Predicted : tensor([12, 28, 63, 35], device='cuda:0')
        Result : tensor([12, 28, 63, 35], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.0907, Validation Accuracy: 97.0046 %

 ---------------------------------------
```









```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 16904), started 0:29:00 ago. (Use '!kill␣
 ↪16904' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

5.2.6 Le modèle « inception_v3 » avec l'optimiseur : SGD

[ ]:
```
size_of_image = [299, 299]
mean = [0.485, 0.456, 0.406]
std = [0.229, 0.224, 0.225]
transform = transforms.Compose([
    transforms.Resize(size_of_image),
    transforms.RandomHorizontalFlip(),
    transforms.ToTensor(),
    transforms.Normalize(mean, std)
])

affiche_dataloader(test_dataloader)

# train_dataloader, test_dataloader = prepare_data(mean, std, size_of_image,␣
 ↪transform, batch_size, split)
train_dataloader, test_dataloader = prepare_data_on_google_colab(mean, std,␣
 ↪size_of_image, transform, batch_size, split)

affiche_dataloader(test_dataloader)
```

[ ]:
```
model_inception_v3 = adapt_pretrained_model("inception_v3")
loss_fn = nn.CrossEntropyLoss()
optimiseur_inception_v3 = torch.optim.SGD(model_inception_v3.parameters(), lr=0.
 ↪001, momentum=0.9)
model_inception_v3_trainTime, model_inception_v3_trainModelComplexity,␣
 ↪model_inception_v3_validation_loss, model_inception_v3_accuracy, _ =␣
 ↪train(model_inception_v3, train_dataloader, test_dataloader, loss_fn,␣
 ↪optimiseur_inception_v3, epochs, typeTrain="inception_v3")
```

5.2.7 Comparaison des modèles

Pour : resnet18 VS alexnet

[ ]:
```
resultTest1 = compare_models(model_resnet18_trainTime,␣
 ↪model_resnet18_trainModelComplexity, model_resnet18_validation_loss,␣
 ↪model_resnet18_accuracy, model_alexnet_trainTime,␣
 ↪model_alexnet_trainModelComplexity, model_alexnet_validation_loss,␣
 ↪model_alexnet_accuracy)
```

```
if resultTest1 == 1:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪resnet18 est le plus performant !
 ↪\n_____________________________________________________\n")
else:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪alexnet est le plus performant !
 ↪\n_____________________________________________________\n")
```

```
Le modèle 1 a une perte de 0.11028738759288734 sur les données de validation
avec une précision de 96.88940092165899% et une complexité de 11228325
paramètres et un temps d'évaluation de 402.37937355041504s

Le modèle 2 a une perte de 0.5426071947228841 sur les données de validation avec
une précision de 87.44239631336406% et une complexité de 57417637 paramètres et
un temps d'évaluation de 332.8651807308197s

        Le modèle 1 a une perte plus faible sur les données de validation.


-----------------------------------------------------
Le Modèle resnet18 est le plus performant !
-----------------------------------------------------
```

Pour : squeezenet1_0 VS vgg16

[ ]:
```
resultTest1 = compare_models(model_squeezenet1_0_trainTime,␣
 ↪model_squeezenet1_0_trainModelComplexity,␣
 ↪model_squeezenet1_0_validation_loss, model_squeezenet1_0_accuracy,␣
 ↪model_vgg16_trainTime, model_vgg16_trainModelComplexity,␣
 ↪model_vgg16_validation_loss, model_vgg16_accuracy)

if resultTest1 == 1:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪squeezenet1_0 est le plus performant !
 ↪\n_____________________________________________________\n")
else:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪vgg16 est le plus performant !
 ↪\n_____________________________________________________\n")
```

```
Le modèle 1 a une perte de 0.45181643231348556 sur les données de validation
avec une précision de 89.40092165898618% et une complexité de 787237 paramètres
et un temps d'évaluation de 386.37032771110535s

Le modèle 2 a une perte de 0.16299629464880458 sur les données de validation
avec une précision de 95.27649769585254% et une complexité de 134674341
paramètres et un temps d'évaluation de 1206.786409854889s
```

```
        Le modèle 2 a une perte plus faible sur les données de validation.

--------------------------------------------------
Le Modèle vgg16 est le plus performant !
--------------------------------------------------
```

Pour : alexnet VS squeezenet1_0

[ ]:
```
resultTest1 = compare_models(model_alexnet_trainTime,␣
 ↪model_alexnet_trainModelComplexity, model_alexnet_validation_loss,␣
 ↪model_alexnet_accuracy, model_squeezenet1_0_trainTime,␣
 ↪model_squeezenet1_0_trainModelComplexity,␣
 ↪model_squeezenet1_0_validation_loss, model_squeezenet1_0_accuracy)

if resultTest1 == 1:
    print("\n_____\nLe Modèle␣
 ↪alexnet est le plus performant !
 ↪\n_____\n")
else:
    print("\n_____\nLe Modèle␣
 ↪squeezenet1_0 est le plus performant !
 ↪\n_____\n")
```

```
Le modèle 1 a une perte de 0.3947000590237704 sur les données de validation avec
une précision de 90.2073732718894% et une complexité de 57417637 paramètres et
un temps d'évaluation de 336.2233576774597s

Le modèle 2 a une perte de 0.45181643231348556 sur les données de validation
avec une précision de 89.40092165898618% et une complexité de 787237 paramètres
et un temps d'évaluation de 386.37032771110535s

        Le modèle 1 a une perte plus faible sur les données de validation.

--------------------------------------------------
Le Modèle alexnet est le plus performant !
--------------------------------------------------
```

Pour : resnet18 VS vgg16

[ ]:
```
resultTest1 = compare_models(model_resnet18_trainTime,␣
 ↪model_resnet18_trainModelComplexity, model_resnet18_validation_loss,␣
 ↪model_resnet18_accuracy, model_vgg16_trainTime,␣
 ↪model_vgg16_trainModelComplexity, model_vgg16_validation_loss,␣
 ↪model_vgg16_accuracy)

if resultTest1 == 1:
```

```
    print("\n_____________________________________________________\nLe Modèle␣
 ↪resnet18 est le plus performant !
 ↪\n_____________________________________________________\n")
else:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪vgg16 est le plus performant !
 ↪\n_____________________________________________________\n")
```

```
Le modèle 1 a une perte de 0.11028738759288734 sur les données de validation
avec une précision de 96.88940092165899% et une complexité de 11228325
paramètres et un temps d'évaluation de 402.37937355041504s

Le modèle 2 a une perte de 0.16299629464880458 sur les données de validation
avec une précision de 95.27649769585254% et une complexité de 134674341
paramètres et un temps d'évaluation de 1206.786409854889s

        Le modèle 1 a une perte plus faible sur les données de validation.


-----------------------------------------------------
Le Modèle resnet18 est le plus performant !
-----------------------------------------------------
```

Pour : resnet18 VS densenet161

[ ]:
```
resultTest1 = compare_models(model_resnet18_trainTime,␣
 ↪model_resnet18_trainModelComplexity, model_resnet18_validation_loss,␣
 ↪model_resnet18_accuracy, model_densenet161_trainTime,␣
 ↪model_densenet161_trainModelComplexity, model_densenet161_validation_loss,␣
 ↪model_densenet161_accuracy)

if resultTest1 == 1:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪resnet18 est le plus performant !
 ↪\n_____________________________________________________\n")
else:
    print("\n_____________________________________________________\nLe Modèle␣
 ↪densenet161 est le plus performant !
 ↪\n_____________________________________________________\n")
```

```
Le modèle 1 a une perte de 0.11028738759288734 sur les données de validation
avec une précision de 96.88940092165899% et une complexité de 11228325
paramètres et un temps d'évaluation de 402.37937355041504s

Le modèle 2 a une perte de 0.09065190162933008 sur les données de validation
avec une précision de 97.00460829493088% et une complexité de 26695109
paramètres et un temps d'évaluation de 1688.1252143383026s

        Le modèle 2 a une perte plus faible sur les données de validation.
```

```
--------------------------------------------------
Le Modèle densenet161 est le plus performant !
--------------------------------------------------
```

Pour : densenet161 VS inception_v3

[ ]:
```
resultTest1 = compare_models(model_densenet161_trainTime,␣
↪model_densenet161_trainModelComplexity, model_densenet161_validation_loss,␣
↪model_densenet161_accuracy, model_inception_v3_trainTime,␣
↪model_inception_v3_trainModelComplexity, model_inception_v3_validation_loss,␣
↪model_inception_v3_accuracy)

if resultTest1 == 1:
    print("\n_____\nLe Modèle␣
↪densenet161 est le plus performant !
↪\n_____\n")
else:
    print("\n_____\nLe Modèle␣
↪inception_v3 est le plus performant !
↪\n_____\n")
```

6 Conlusion

Nous pouvons donc conclure que parmi les cinq (5) modèles suivant : resnet18, alexnet, squeezenet1_0, vgg16 et densenet161. Le modèle le plus performant par ordre croissant est : * densenet161 (1er) * resnet18 (2e) * alexnet (3e) * vgg16 (4e) * squeezenet1_0 (5e)

N.B. inception_v3 (???)

Concernant le modèle Inception_v3, dû à une faible puissant de mon GPU, je n'ai pas reussi à le tester. Pour pouvoir procéder au test, il me fallait payer un abonnement sur Google Colab afin d'avoir les ressources nécessaires pour permettre l'exécution de ma fonction train.

7 Exécution des boucles d'apprentissage pour k itération

[5]:
```
def boucle_de_validation_croisee_pour_k_iteration(model, train_loader,␣
↪validation_loader, loss_fn, optimizer, epochs, typeTrain="deepLearning",␣
↪k=10):
    scores_total = []
    for i in range(k):
        # train_dataloader, test_dataloader = prepare_data(mean, std,␣
↪size_of_image, transform, batch_size, split)
        train_dataloader, test_dataloader = prepare_data_on_google_colab(mean,␣
↪std, size_of_image, transform, batch_size, split)

        # Apprentissage des données sur le Train et la Validation
```

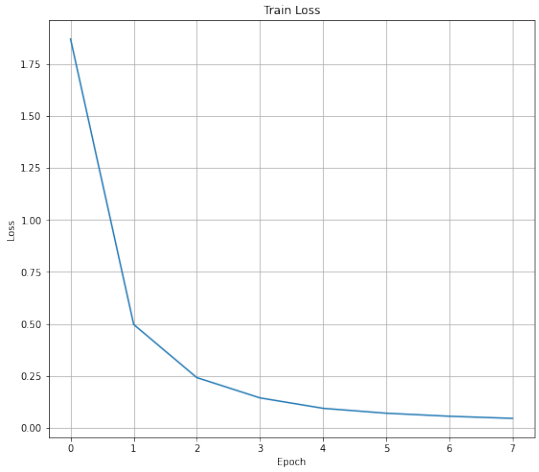
```
        _, _, _, _, scores = train(model, train_loader, validation_loader,␣
 ↪loss_fn, optimizer, epochs, typeTrain="deepLearning")
        scores_total += scores

    # Calcul de la moyenne des scores sur les k itérations
    mean_score = sum(scores_total) / k
    print("La moyenne des accuracy: {:.4f} %".format(mean_score * 100.0))
    return mean_score
```

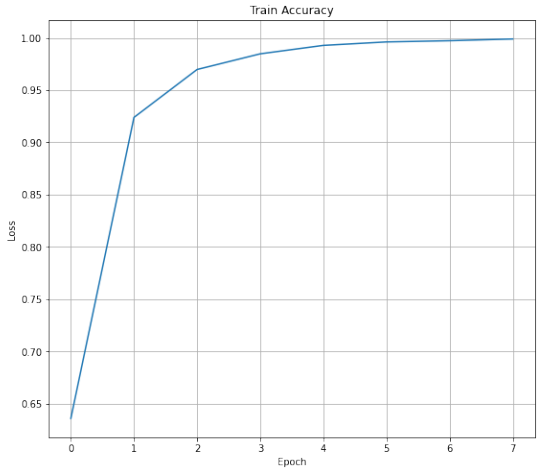
7.1 Pour le modèle resnet18 avec K = 10

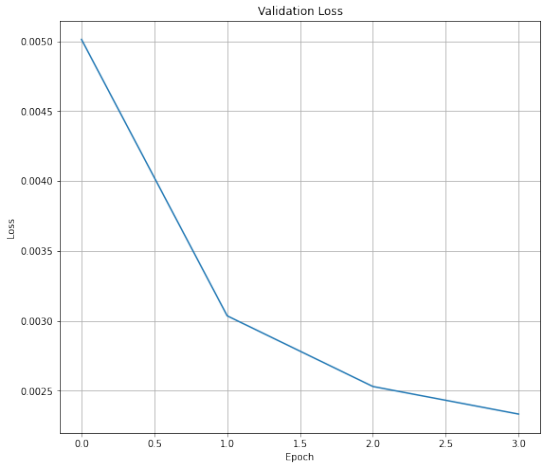
[7]:
```
model_resnet18 = adapt_pretrained_model("resnet18")
loss_fn = nn.CrossEntropyLoss()
optimiseur_resnet18 = torch.optim.SGD(model_resnet18.parameters(), lr=0.001,␣
 ↪momentum=0.9)

mean_resnet18 = boucle_de_validation_croisee_pour_k_iteration(model_resnet18,␣
 ↪train_dataloader, test_dataloader, loss_fn, optimiseur_resnet18, epochs,␣
 ↪typeTrain="resnet18")
```

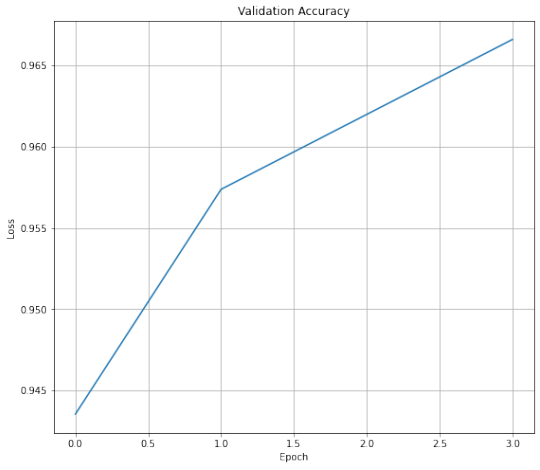
```
Downloading: "https://download.pytorch.org/models/resnet18-f37072fd.pth" to
/root/.cache/torch/hub/checkpoints/resnet18-f37072fd.pth

  0%|          | 0.00/44.7M [00:00<?, ?B/s]

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.8704, Train Accuracy: 63.5933 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 819.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.2757, Validation Accuracy: 94.3548 %
Epoch 3, Train Loss: 0.2413, Train Accuracy: 96.9778 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 831.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1669, Validation Accuracy: 95.7373 %
Epoch 5, Train Loss: 0.0936, Train Accuracy: 99.2829 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 835.0 / 868.0
```

```
 ----------------------------------------
Epoch 6, Validation Loss: 0.1391, Validation Accuracy: 96.1982 %
Epoch 7, Train Loss: 0.0555, Train Accuracy: 99.7311 %
 ----------------------------------------
Predicted : tensor([94, 88, 20, 12], device='cuda:0')
Result : tensor([94, 88, 20, 12], device='cuda:0')
TOTAL (correct/total): 839.0 / 868.0
 ----------------------------------------
Epoch 8, Validation Loss: 0.1283, Validation Accuracy: 96.6590 %

----------------------------------------
```



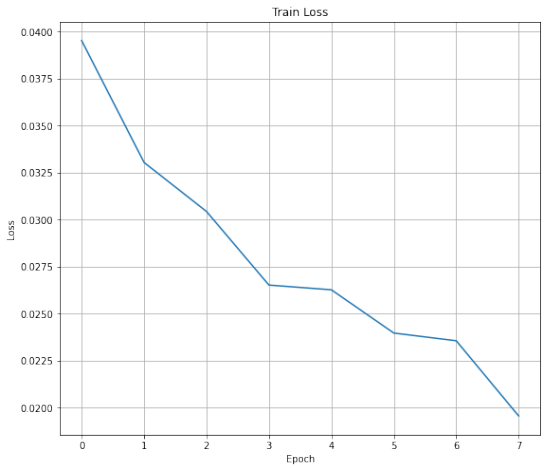


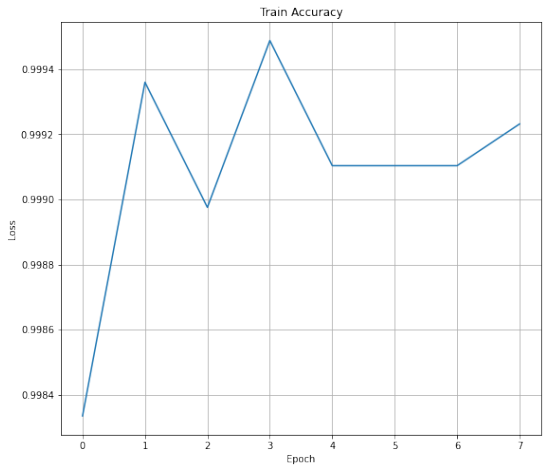


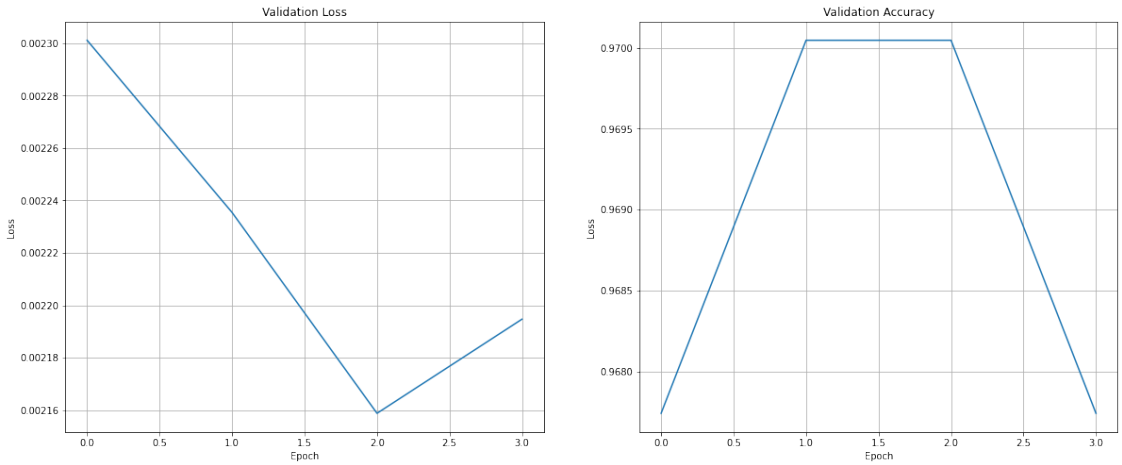



```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
```

```
Device is : cuda:0

 ---------------------------------------
Epoch 1, Train Loss: 0.0395, Train Accuracy: 99.8335 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ---------------------------------------
        Epoch 2, Validation Loss: 0.1266, Validation Accuracy: 96.7742 %
Epoch 3, Train Loss: 0.0304, Train Accuracy: 99.8976 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ---------------------------------------
        Epoch 4, Validation Loss: 0.1229, Validation Accuracy: 97.0046 %
Epoch 5, Train Loss: 0.0263, Train Accuracy: 99.9104 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ---------------------------------------
        Epoch 6, Validation Loss: 0.1187, Validation Accuracy: 97.0046 %
Epoch 7, Train Loss: 0.0236, Train Accuracy: 99.9104 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.1207, Validation Accuracy: 96.7742 %

 ---------------------------------------
```

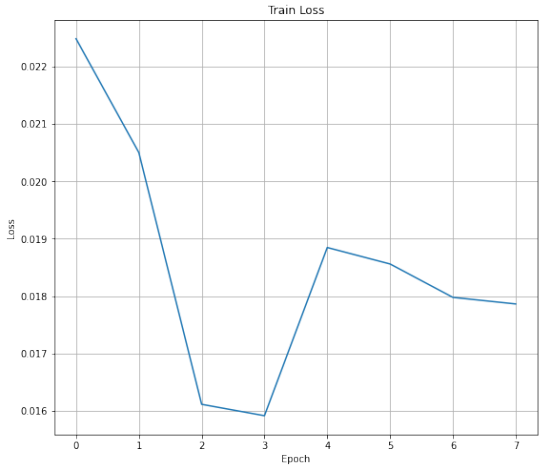


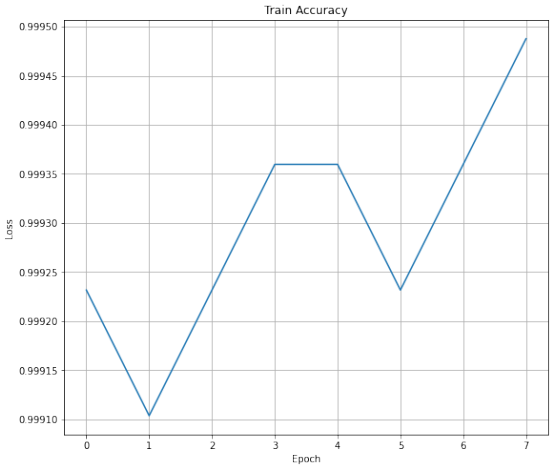


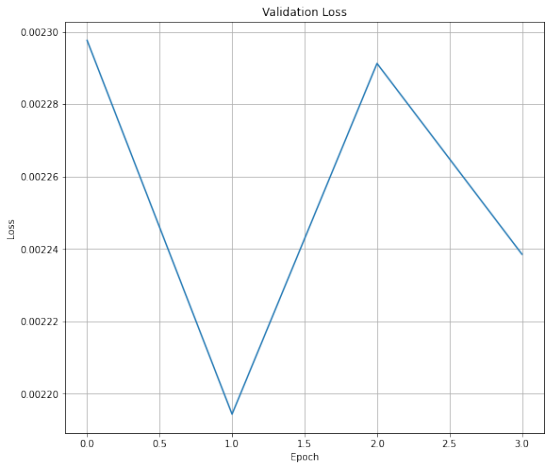


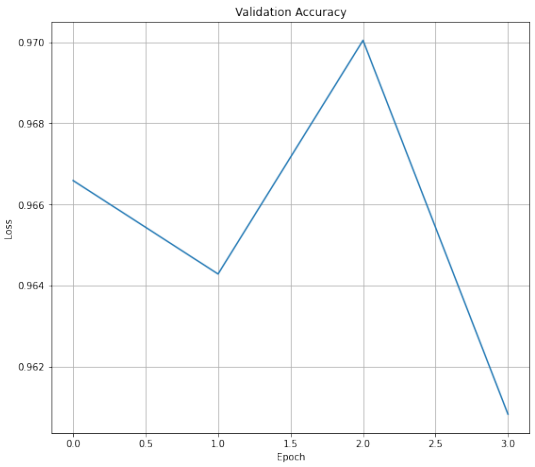

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:06:44 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0225, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1264, Validation Accuracy: 96.6590 %
Epoch 3, Train Loss: 0.0161, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 837.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1207, Validation Accuracy: 96.4286 %
Epoch 5, Train Loss: 0.0188, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
```

```
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1260, Validation Accuracy: 97.0046 %
Epoch 7, Train Loss: 0.0180, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 834.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1231, Validation Accuracy: 96.0829 %

 ----------------------------------------
```



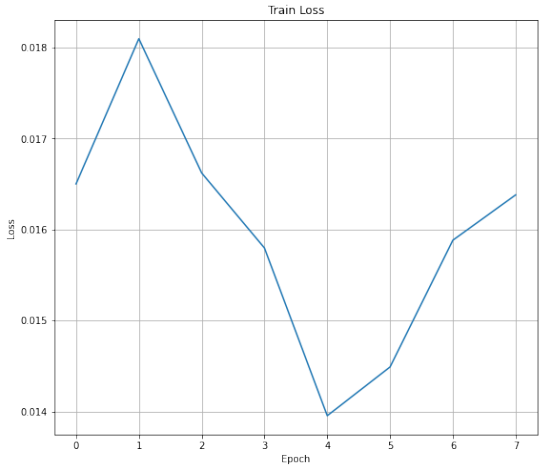


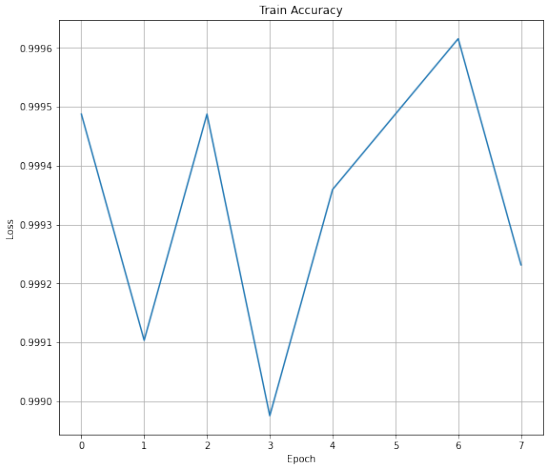


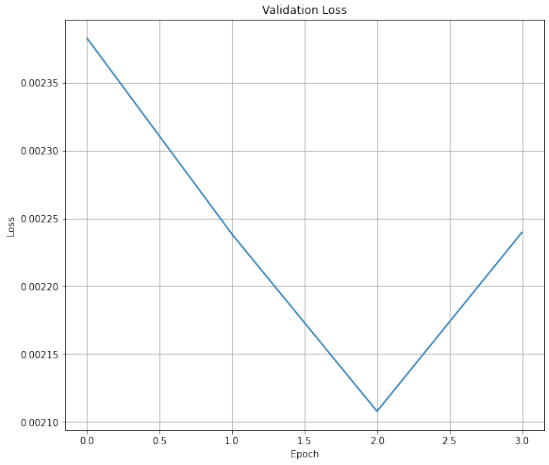


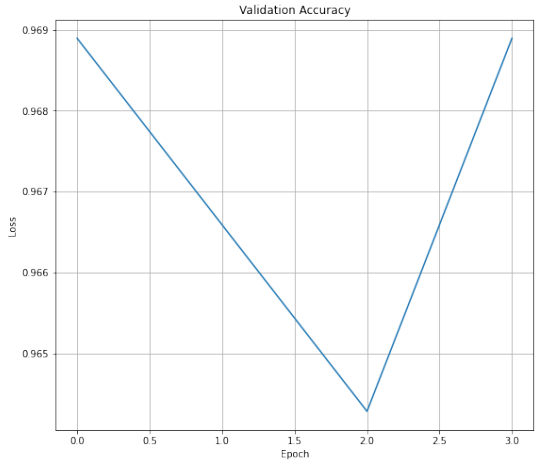

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 3547), started 0:13:25 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0165, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1311, Validation Accuracy: 96.8894 %
Epoch 3, Train Loss: 0.0166, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1231, Validation Accuracy: 96.6590 %
Epoch 5, Train Loss: 0.0140, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 837.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1159, Validation Accuracy: 96.4286 %
Epoch 7, Train Loss: 0.0159, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1232, Validation Accuracy: 96.8894 %

 ----------------------------------------
```



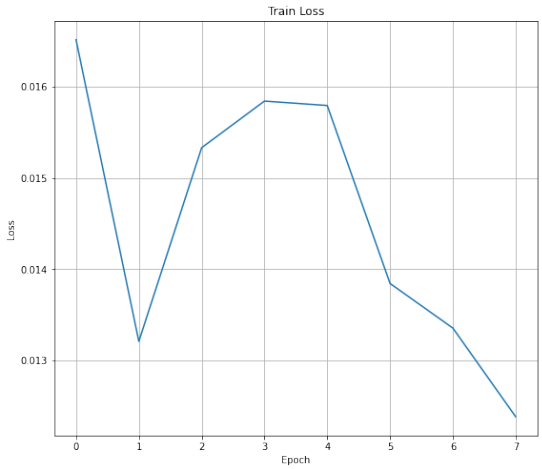


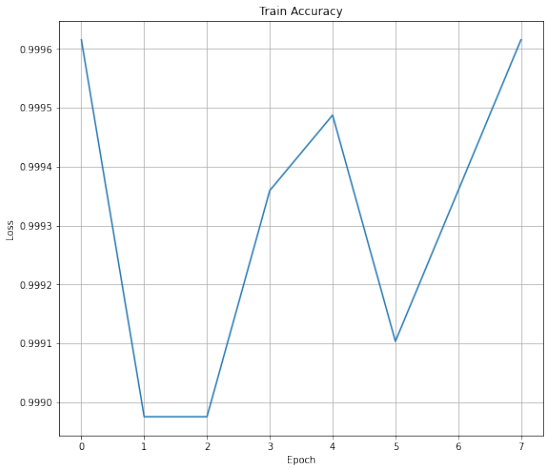


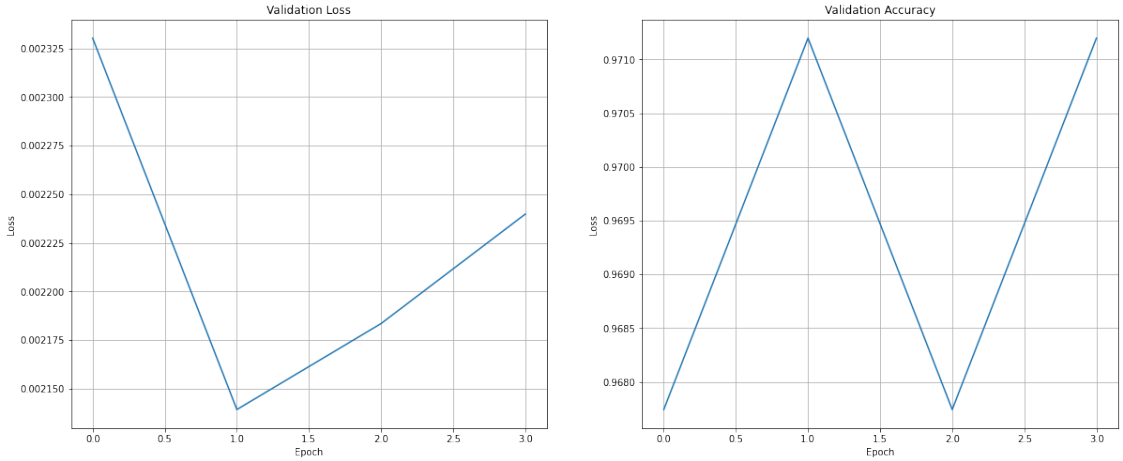



```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:20:05 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0165, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
```

```
        TOTAL (correct/total): 840.0 / 868.0
         ---------------------------------------
        Epoch 2, Validation Loss: 0.1282, Validation Accuracy: 96.7742 %
Epoch 3, Train Loss: 0.0153, Train Accuracy: 99.8976 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         ---------------------------------------
        Epoch 4, Validation Loss: 0.1177, Validation Accuracy: 97.1198 %
Epoch 5, Train Loss: 0.0158, Train Accuracy: 99.9488 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ---------------------------------------
        Epoch 6, Validation Loss: 0.1201, Validation Accuracy: 96.7742 %
Epoch 7, Train Loss: 0.0134, Train Accuracy: 99.9360 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.1232, Validation Accuracy: 97.1198 %

 ----------------------------------------
```

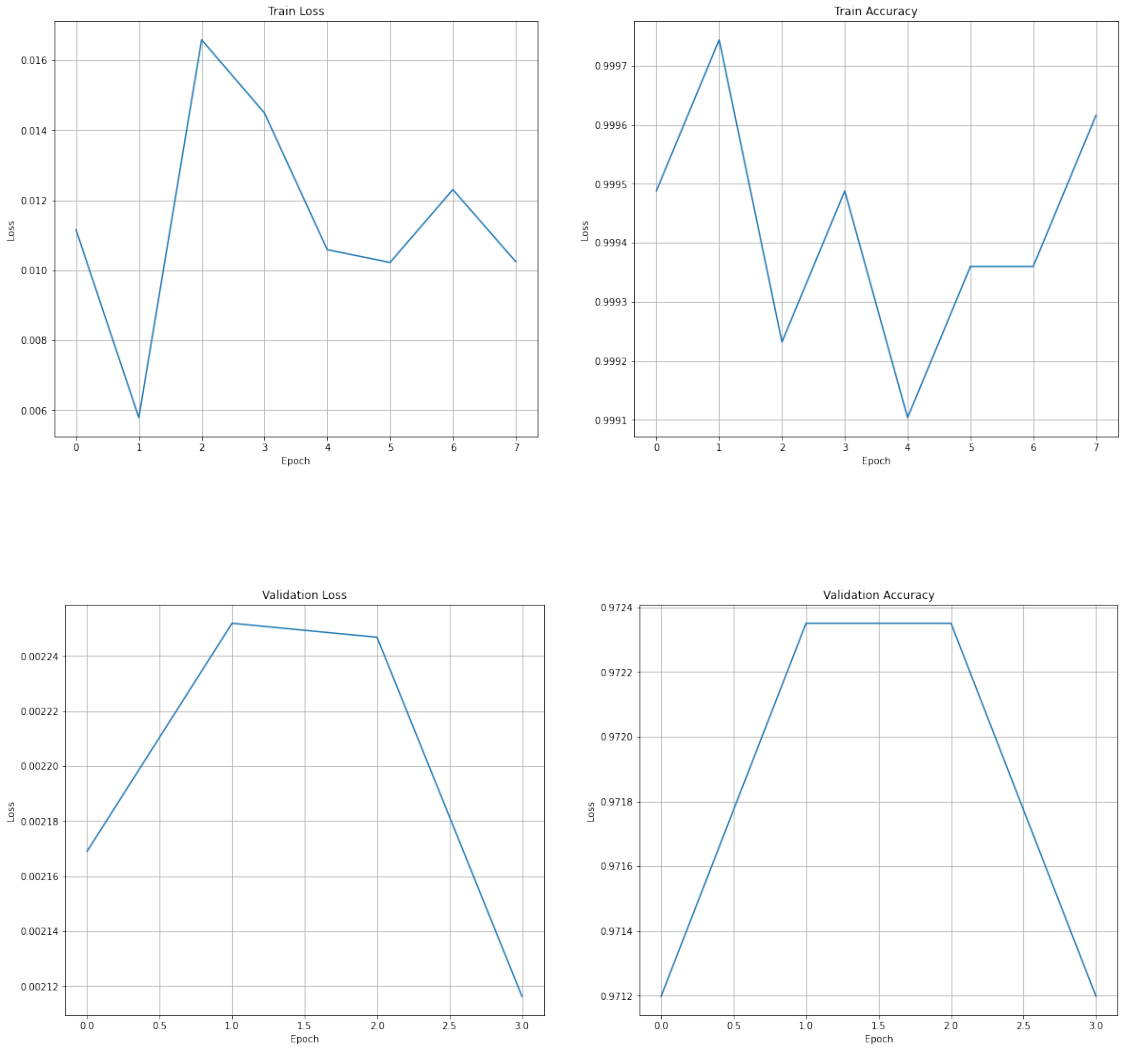






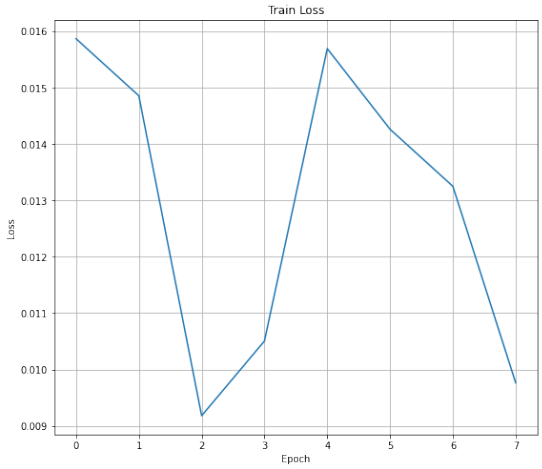

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:26:44 ago. (Use '!kill␣
  ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0112, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1193, Validation Accuracy: 97.1198 %
Epoch 3, Train Loss: 0.0166, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 844.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1239, Validation Accuracy: 97.2350 %
Epoch 5, Train Loss: 0.0106, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 844.0 / 868.0
         ----------------------------------------
```

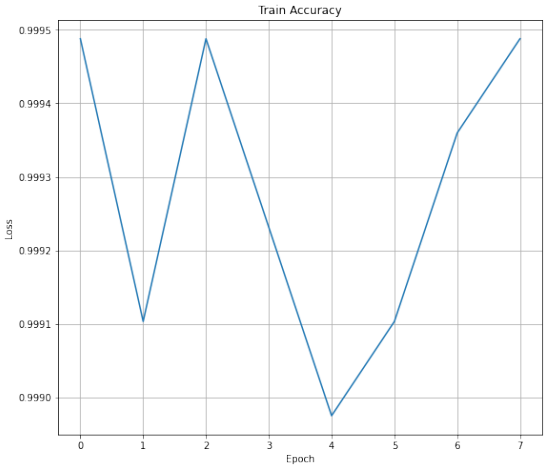
```
        Epoch 6, Validation Loss: 0.1236, Validation Accuracy: 97.2350 %
Epoch 7, Train Loss: 0.0123, Train Accuracy: 99.9360 %
         --------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         --------------------------------------
        Epoch 8, Validation Loss: 0.1164, Validation Accuracy: 97.1198 %

 --------------------------------------
```

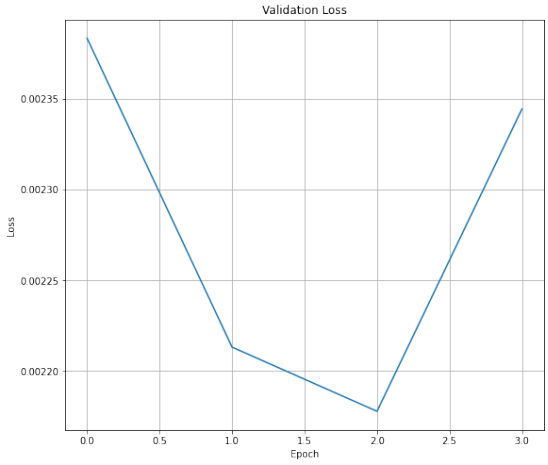


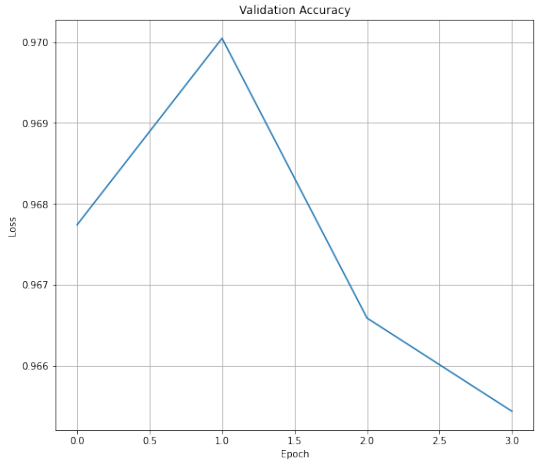

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:33:27 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0159, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1311, Validation Accuracy: 96.7742 %
Epoch 3, Train Loss: 0.0092, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1217, Validation Accuracy: 97.0046 %
Epoch 5, Train Loss: 0.0157, Train Accuracy: 99.8976 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1198, Validation Accuracy: 96.6590 %
Epoch 7, Train Loss: 0.0133, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1289, Validation Accuracy: 96.5438 %

 ----------------------------------------
```



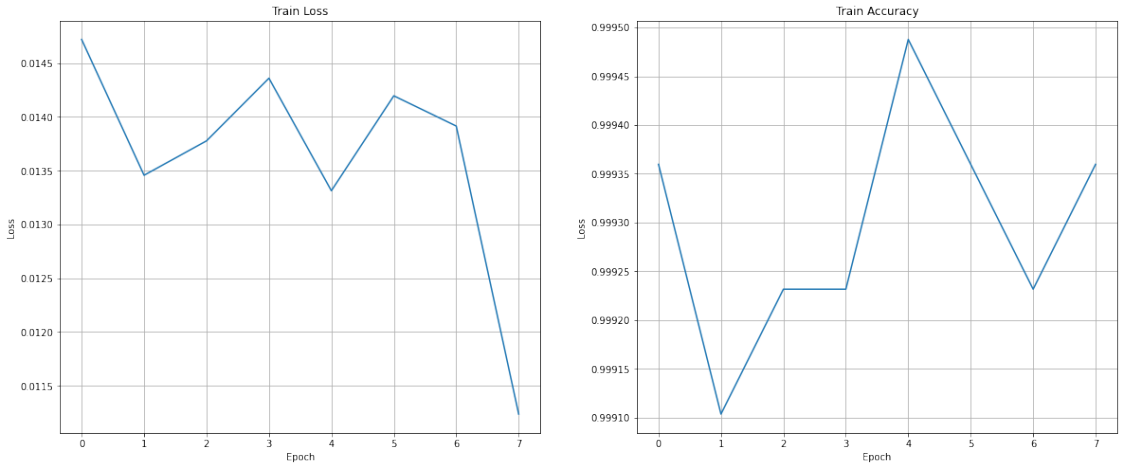


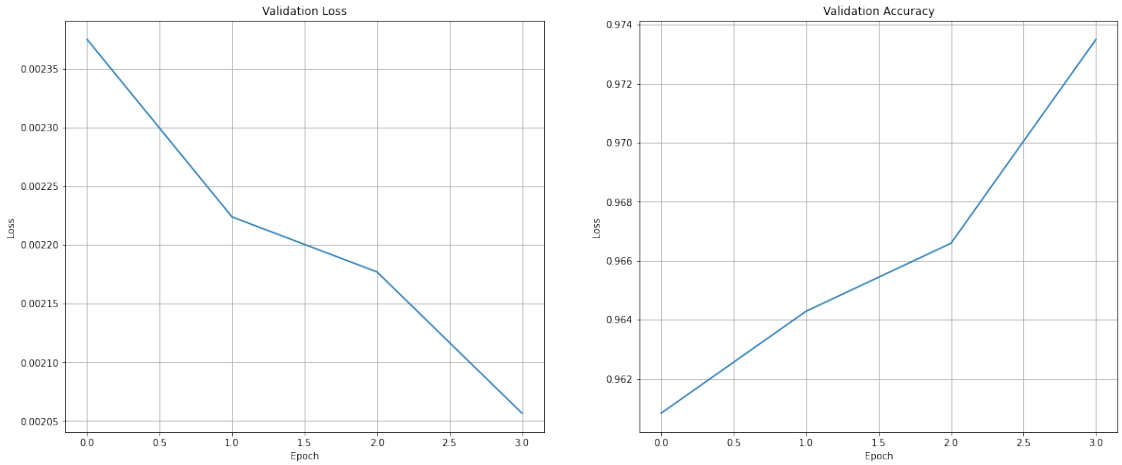





```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:40:09 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0147, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
```

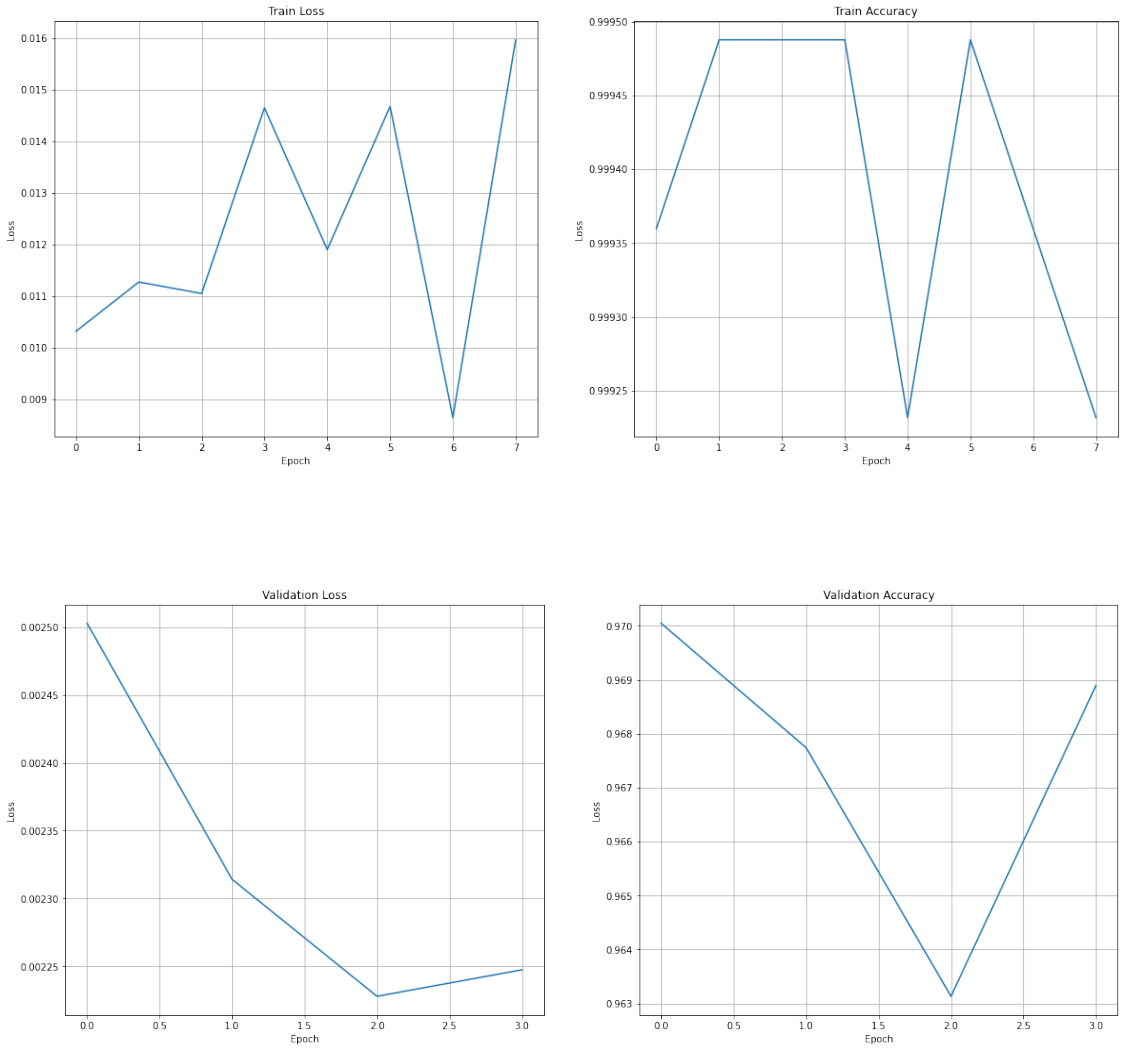
```
        TOTAL (correct/total): 834.0 / 868.0
         ---------------------------------------
        Epoch 2, Validation Loss: 0.1306, Validation Accuracy: 96.0829 %
Epoch 3, Train Loss: 0.0138, Train Accuracy: 99.9232 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 837.0 / 868.0
         ---------------------------------------
        Epoch 4, Validation Loss: 0.1223, Validation Accuracy: 96.4286 %
Epoch 5, Train Loss: 0.0133, Train Accuracy: 99.9488 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ---------------------------------------
        Epoch 6, Validation Loss: 0.1197, Validation Accuracy: 96.6590 %
Epoch 7, Train Loss: 0.0139, Train Accuracy: 99.9232 %
         ---------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 845.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.1131, Validation Accuracy: 97.3502 %

 ----------------------------------------
```





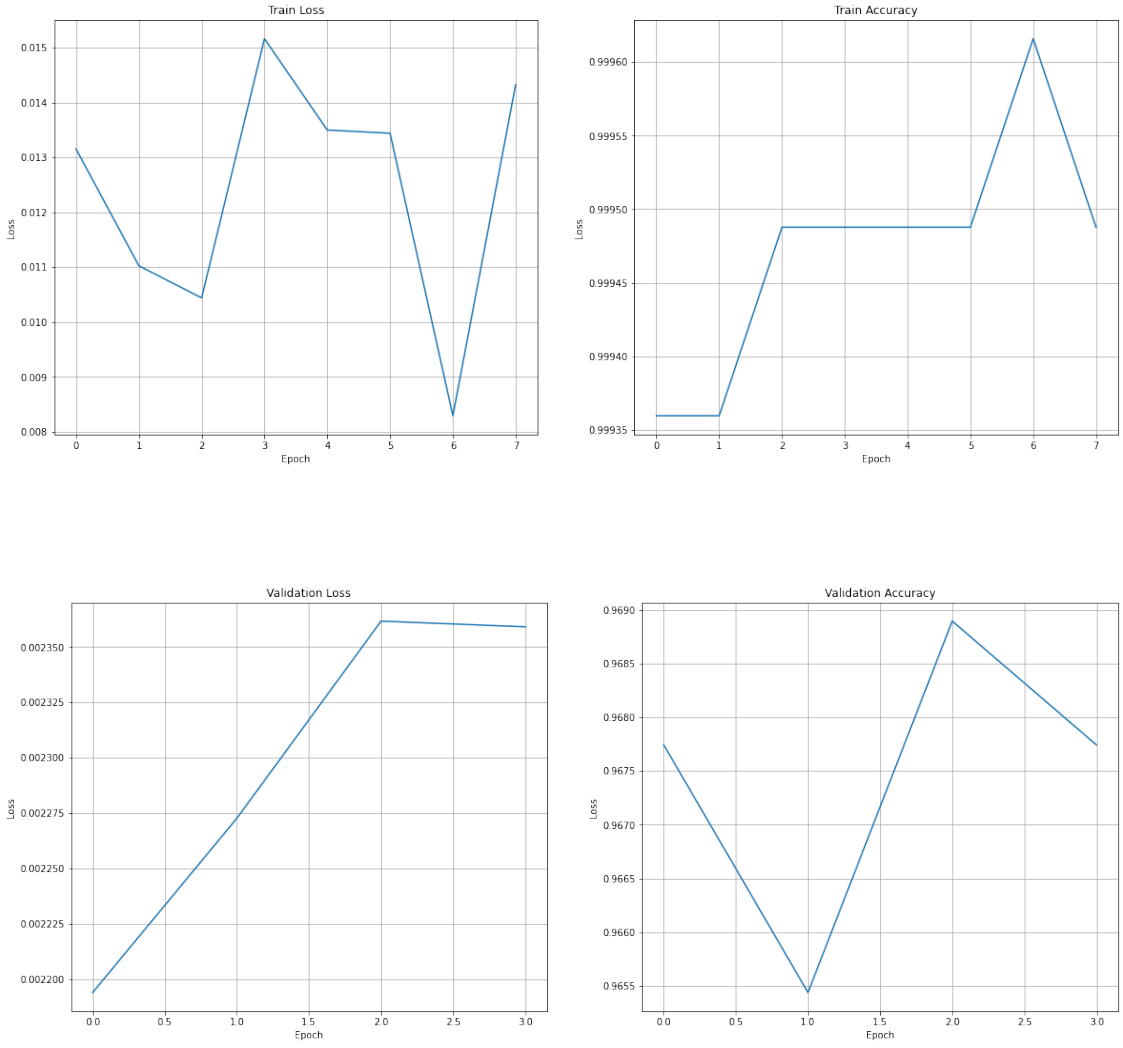

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:46:51 ago. (Use '!kill␣
  ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0103, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1376, Validation Accuracy: 97.0046 %
Epoch 3, Train Loss: 0.0111, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1273, Validation Accuracy: 96.7742 %
Epoch 5, Train Loss: 0.0119, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 836.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 0.1225, Validation Accuracy: 96.3134 %
Epoch 7, Train Loss: 0.0086, Train Accuracy: 99.9360 %
         --------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         --------------------------------------
        Epoch 8, Validation Loss: 0.1236, Validation Accuracy: 96.8894 %

 ----------------------------------------
```




```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 0:53:28 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0132, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1207, Validation Accuracy: 96.7742 %
Epoch 3, Train Loss: 0.0104, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1250, Validation Accuracy: 96.5438 %
Epoch 5, Train Loss: 0.0135, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1299, Validation Accuracy: 96.8894 %
Epoch 7, Train Loss: 0.0083, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([94, 88, 20, 12], device='cuda:0')
        Result : tensor([94, 88, 20, 12], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1298, Validation Accuracy: 96.7742 %

 ----------------------------------------
```




```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 3547), started 1:00:07 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

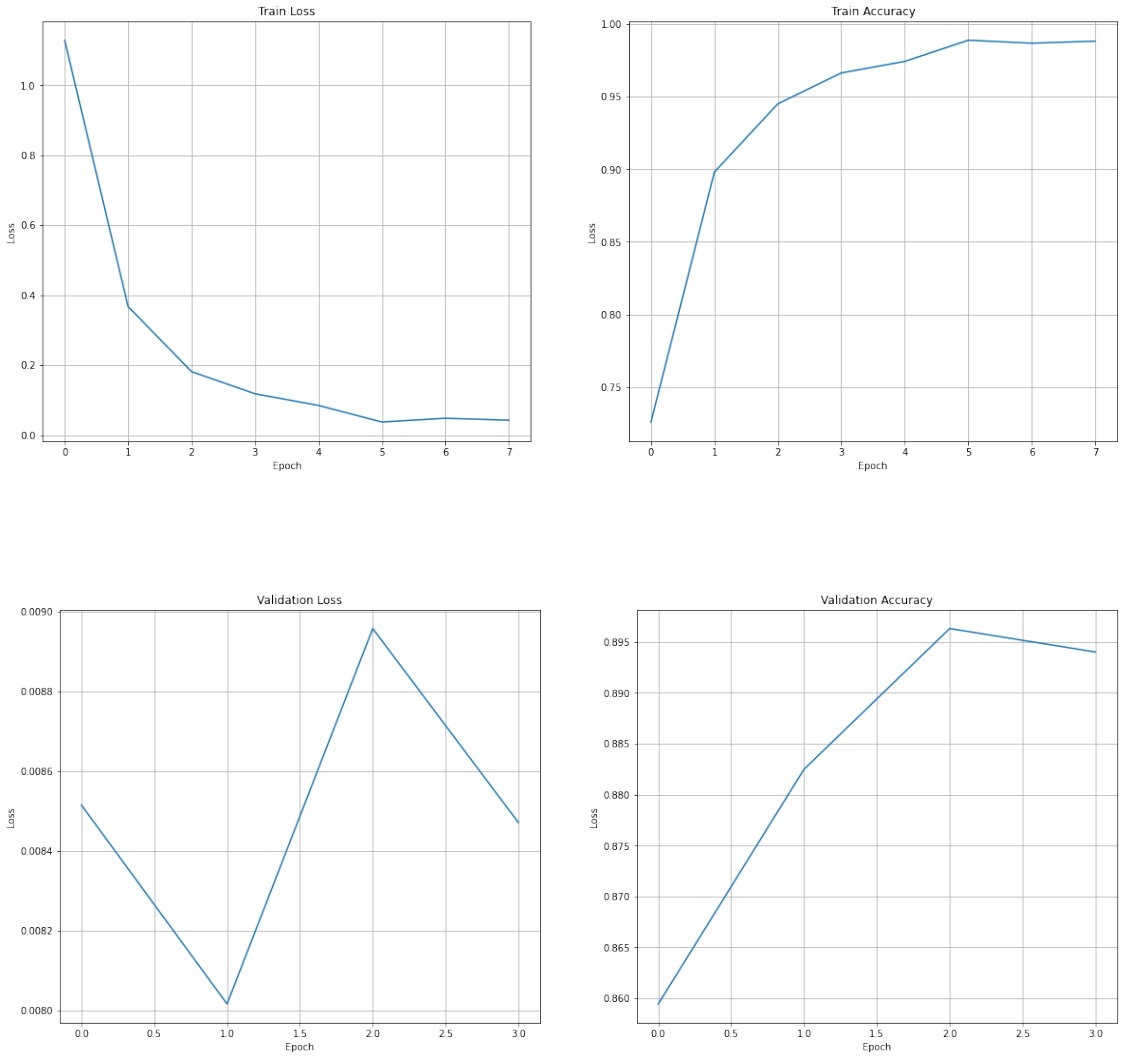
```
La moyenne des accuracy: 386.7512 %
```

7.2 Pour le modèle alexnet avec K = 10

[10]:
```
model_alexnet = adapt_pretrained_model("alexnet")
loss_fn = nn.CrossEntropyLoss()
optimiseur_alexnet = torch.optim.SGD(model_alexnet.parameters(), lr=0.001,␣
 ↪momentum=0.9)
```

```
mean_alexnet = boucle_de_validation_croisee_pour_k_iteration(model_alexnet,␣
↪train_dataloader, test_dataloader, loss_fn, optimiseur_alexnet, epochs,␣
↪typeTrain="alexnet")
```

```
Downloading: "https://download.pytorch.org/models/alexnet-owt-7be5be79.pth" to
/root/.cache/torch/hub/checkpoints/alexnet-owt-7be5be79.pth

  0%|          | 0.00/233M [00:00<?, ?B/s]

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.1285, Train Accuracy: 72.5829 %
         ----------------------------------------
        Predicted : tensor([78,  5, 90, 19], device='cuda:0')
        Result : tensor([78,  5, 90, 19], device='cuda:0')
        TOTAL (correct/total): 746.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4684, Validation Accuracy: 85.9447 %
Epoch 3, Train Loss: 0.1812, Train Accuracy: 94.5063 %
         ----------------------------------------
        Predicted : tensor([ 0, 79, 58, 86], device='cuda:0')
        Result : tensor([ 0, 79, 36, 26], device='cuda:0')
        TOTAL (correct/total): 766.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4409, Validation Accuracy: 88.2488 %
Epoch 5, Train Loss: 0.0847, Train Accuracy: 97.4260 %
         ----------------------------------------
        Predicted : tensor([75, 72,  5,  3], device='cuda:0')
        Result : tensor([82, 72,  5,  3], device='cuda:0')
        TOTAL (correct/total): 778.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.4927, Validation Accuracy: 89.6313 %
Epoch 7, Train Loss: 0.0481, Train Accuracy: 98.6810 %
         ----------------------------------------
        Predicted : tensor([22, 36, 59,  0], device='cuda:0')
        Result : tensor([98, 76, 59,  0], device='cuda:0')
        TOTAL (correct/total): 776.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4659, Validation Accuracy: 89.4009 %

 ----------------------------------------
```




```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

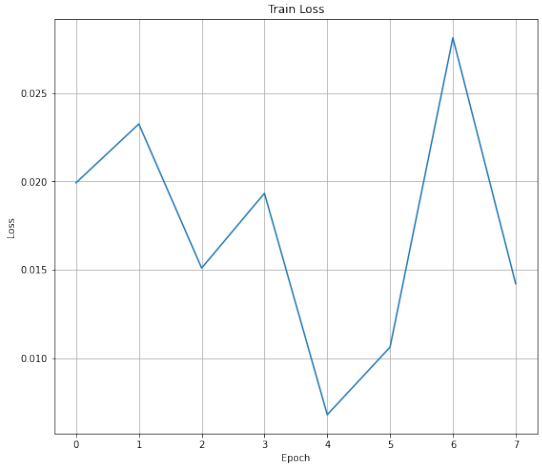
```
Reusing TensorBoard on port 6006 (pid 3547), started 1:05:40 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

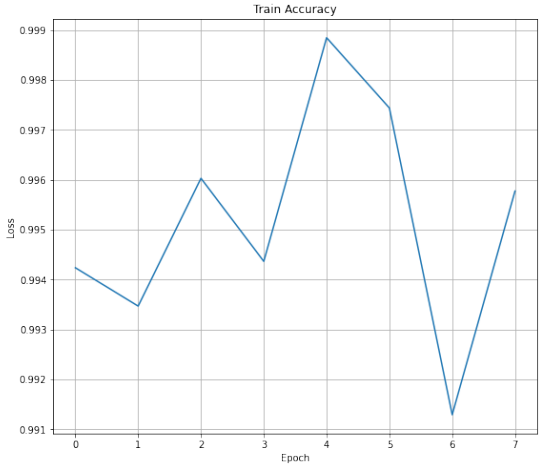
```
<IPython.core.display.Javascript object>
```

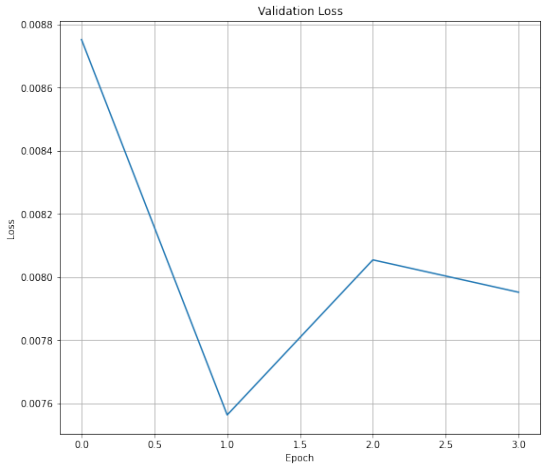
```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0
```

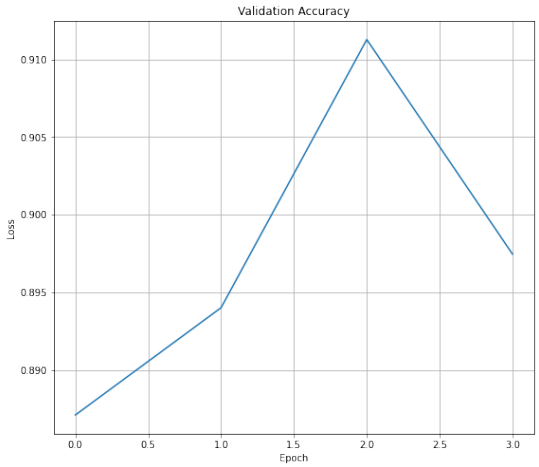
```
 ----------------------------------------
Epoch 1, Train Loss: 0.0199, Train Accuracy: 99.4237 %
         ----------------------------------------
        Predicted : tensor([12, 35, 39, 93], device='cuda:0')
```

```
        Result : tensor([12, 35, 39, 84], device='cuda:0')
        TOTAL (correct/total): 770.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4814, Validation Accuracy: 88.7097 %
Epoch 3, Train Loss: 0.0151, Train Accuracy: 99.6030 %
         ----------------------------------------
        Predicted : tensor([27,  3, 33, 12], device='cuda:0')
        Result : tensor([27,  3, 33, 12], device='cuda:0')
        TOTAL (correct/total): 776.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4160, Validation Accuracy: 89.4009 %
Epoch 5, Train Loss: 0.0068, Train Accuracy: 99.8847 %
         ----------------------------------------
        Predicted : tensor([ 1, 51,  5,  5], device='cuda:0')
        Result : tensor([ 1, 51,  5,  5], device='cuda:0')
        TOTAL (correct/total): 791.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.4430, Validation Accuracy: 91.1290 %
Epoch 7, Train Loss: 0.0281, Train Accuracy: 99.1292 %
         ----------------------------------------
        Predicted : tensor([ 0,  3,  5, 79], device='cuda:0')
        Result : tensor([ 0,  3,  5, 79], device='cuda:0')
        TOTAL (correct/total): 779.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4374, Validation Accuracy: 89.7465 %

 ----------------------------------------
```



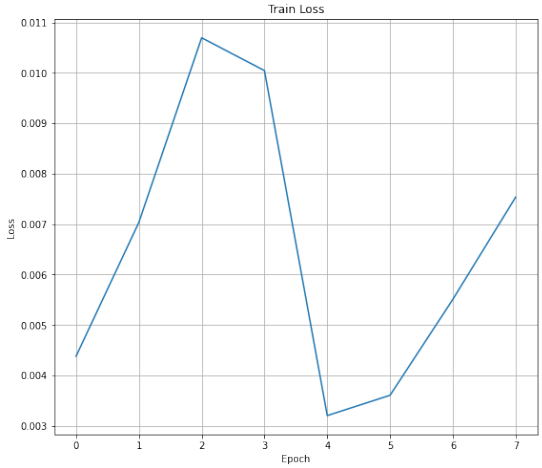


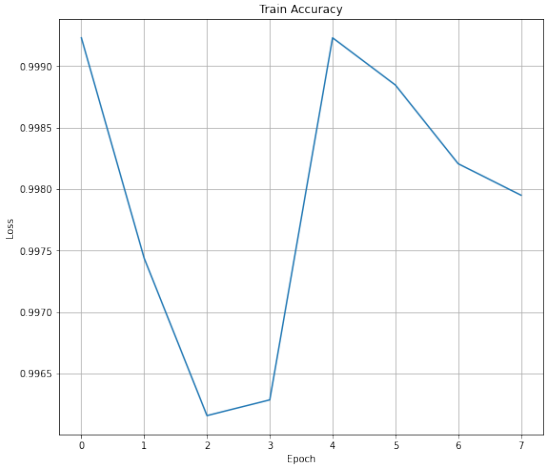


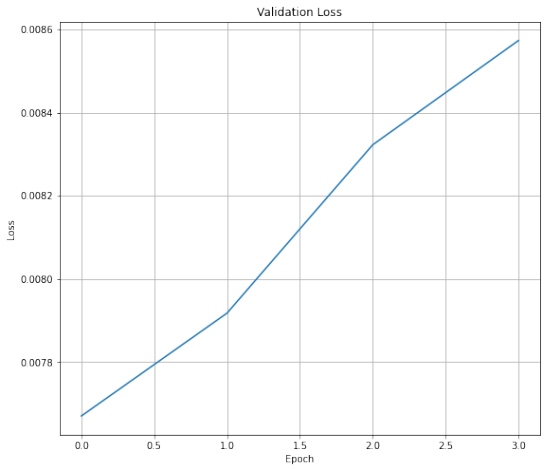


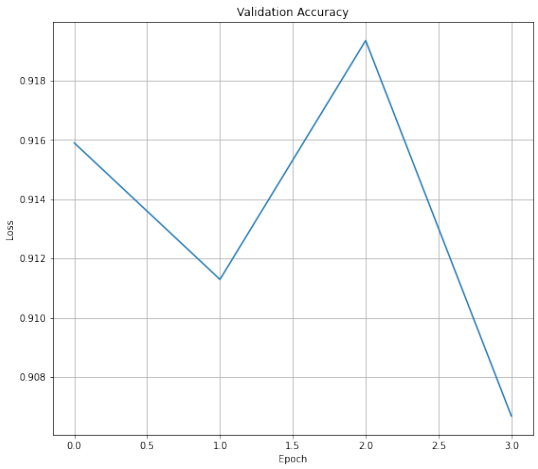

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:11:05 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0044, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([22, 97,  1, 62], device='cuda:0')
        Result : tensor([22, 97,  1, 62], device='cuda:0')
        TOTAL (correct/total): 795.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4219, Validation Accuracy: 91.5899 %
Epoch 3, Train Loss: 0.0107, Train Accuracy: 99.6158 %
         ----------------------------------------
        Predicted : tensor([94, 57, 96,  3], device='cuda:0')
        Result : tensor([17, 57, 96,  3], device='cuda:0')
        TOTAL (correct/total): 791.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4355, Validation Accuracy: 91.1290 %
Epoch 5, Train Loss: 0.0032, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([ 5,  5, 98, 32], device='cuda:0')
        Result : tensor([ 5,  5, 98, 32], device='cuda:0')
        TOTAL (correct/total): 798.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 0.4577, Validation Accuracy: 91.9355 %
Epoch 7, Train Loss: 0.0055, Train Accuracy: 99.8207 %
         ---------------------------------------
        Predicted : tensor([ 0,  5, 78, 14], device='cuda:0')
        Result : tensor([ 0,  5, 78, 14], device='cuda:0')
        TOTAL (correct/total): 787.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.4715, Validation Accuracy: 90.6682 %

 ---------------------------------------
```



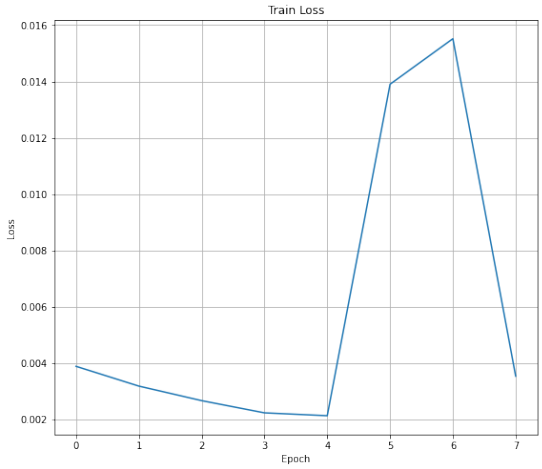


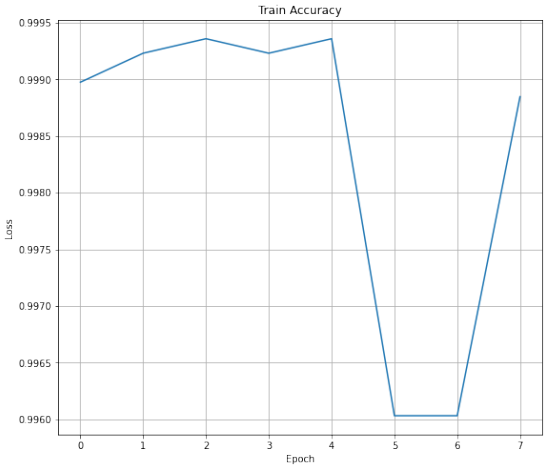


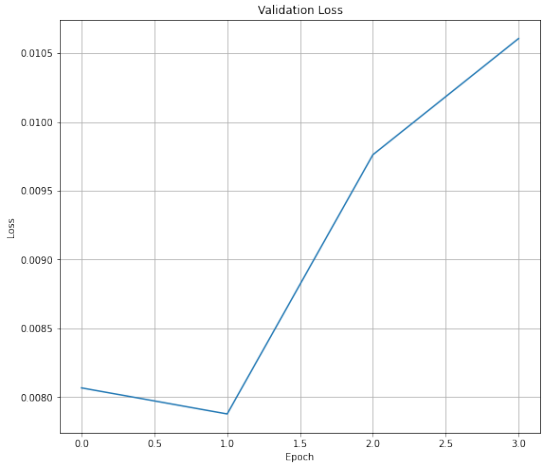


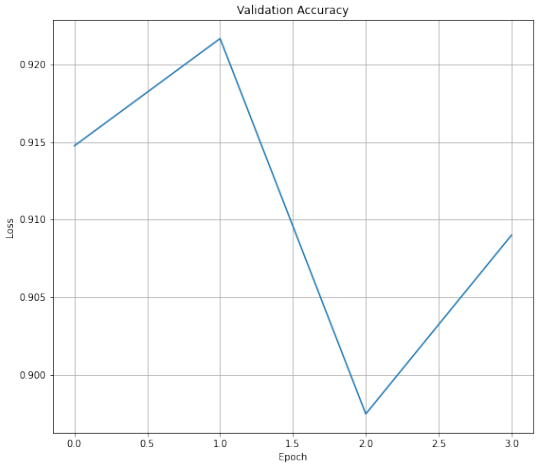

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:16:28 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0039, Train Accuracy: 99.8976 %
         ----------------------------------------
        Predicted : tensor([92, 54, 22, 92], device='cuda:0')
        Result : tensor([92, 54,  6, 92], device='cuda:0')
        TOTAL (correct/total): 794.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4437, Validation Accuracy: 91.4747 %
Epoch 3, Train Loss: 0.0027, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([33, 84, 43, 23], device='cuda:0')
        Result : tensor([33, 84, 43, 23], device='cuda:0')
        TOTAL (correct/total): 800.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4333, Validation Accuracy: 92.1659 %
Epoch 5, Train Loss: 0.0021, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([ 3, 60, 90, 51], device='cuda:0')
        Result : tensor([ 3, 60, 90, 51], device='cuda:0')
        TOTAL (correct/total): 779.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.5369, Validation Accuracy: 89.7465 %
Epoch 7, Train Loss: 0.0155, Train Accuracy: 99.6030 %
         ----------------------------------------
        Predicted : tensor([75, 58, 37, 14], device='cuda:0')
        Result : tensor([75, 58, 37, 14], device='cuda:0')
        TOTAL (correct/total): 789.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.5834, Validation Accuracy: 90.8986 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

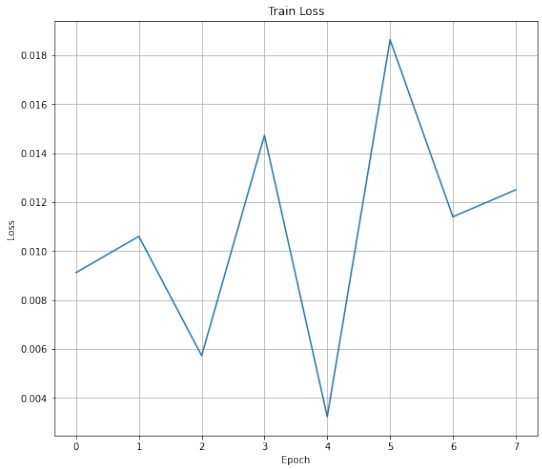
```
Reusing TensorBoard on port 6006 (pid 3547), started 1:21:49 ago. (Use '!kill␣
  ↪3547' to kill it.)
```

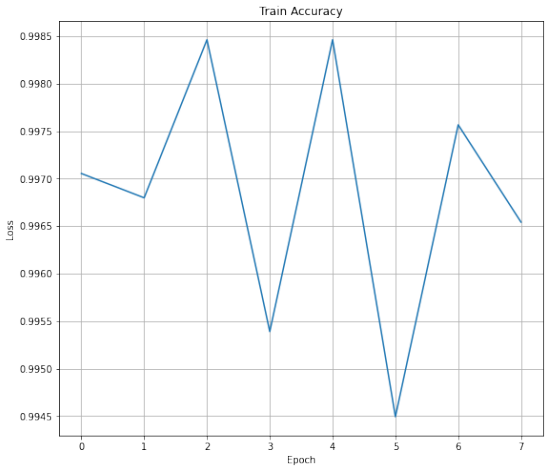
```
<IPython.core.display.Javascript object>
```

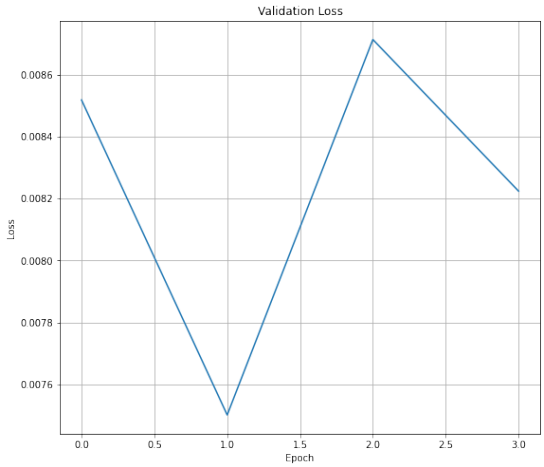
```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0
```

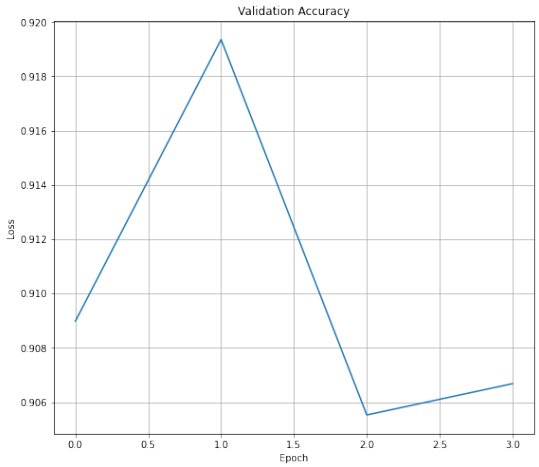
```
 ----------------------------------------
Epoch 1, Train Loss: 0.0091, Train Accuracy: 99.7055 %
         ----------------------------------------
        Predicted : tensor([1, 3, 0, 3], device='cuda:0')
        Result : tensor([1, 3, 0, 3], device='cuda:0')
```

```
        TOTAL (correct/total): 789.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4685, Validation Accuracy: 90.8986 %
Epoch 3, Train Loss: 0.0057, Train Accuracy: 99.8463 %
         ----------------------------------------
        Predicted : tensor([ 5, 17, 75, 79], device='cuda:0')
        Result : tensor([ 5, 17, 75, 79], device='cuda:0')
        TOTAL (correct/total): 798.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4126, Validation Accuracy: 91.9355 %
Epoch 5, Train Loss: 0.0032, Train Accuracy: 99.8463 %
         ----------------------------------------
        Predicted : tensor([44,  1, 50, 80], device='cuda:0')
        Result : tensor([44,  1, 18, 80], device='cuda:0')
        TOTAL (correct/total): 786.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.4792, Validation Accuracy: 90.5530 %
Epoch 7, Train Loss: 0.0114, Train Accuracy: 99.7567 %
         ----------------------------------------
        Predicted : tensor([26,  0,  3, 48], device='cuda:0')
        Result : tensor([27,  0,  3, 48], device='cuda:0')
        TOTAL (correct/total): 787.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4523, Validation Accuracy: 90.6682 %

 ----------------------------------------
```



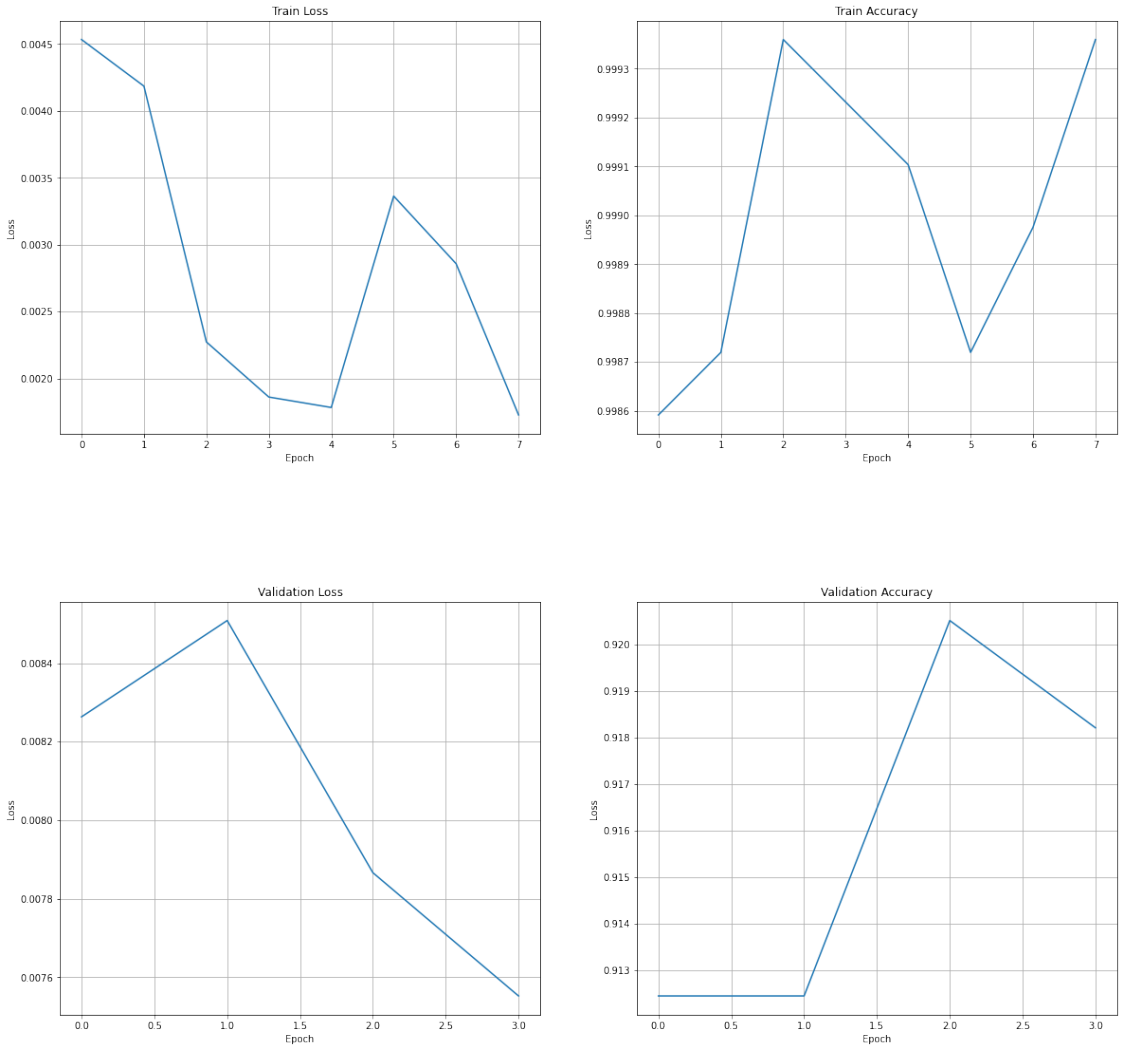






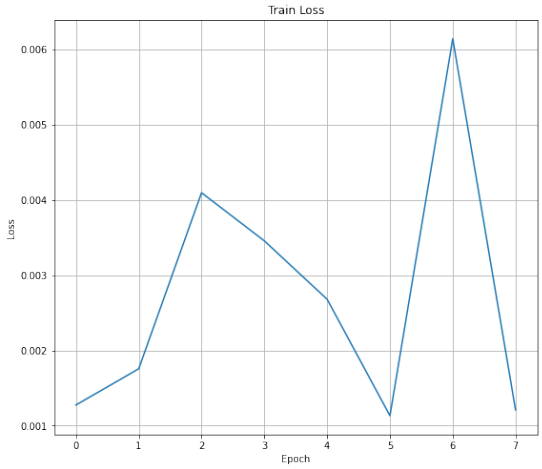

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:27:20 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0045, Train Accuracy: 99.8591 %
         ----------------------------------------
        Predicted : tensor([47,  5, 92, 90], device='cuda:0')
        Result : tensor([47,  5, 92, 90], device='cuda:0')
        TOTAL (correct/total): 792.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4545, Validation Accuracy: 91.2442 %
Epoch 3, Train Loss: 0.0023, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([69, 55,  3, 78], device='cuda:0')
        Result : tensor([69, 79,  3, 78], device='cuda:0')
        TOTAL (correct/total): 792.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4680, Validation Accuracy: 91.2442 %
Epoch 5, Train Loss: 0.0018, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([ 5, 20, 75,  2], device='cuda:0')
        Result : tensor([ 5, 20, 82,  2], device='cuda:0')
        TOTAL (correct/total): 799.0 / 868.0
         ----------------------------------------
```

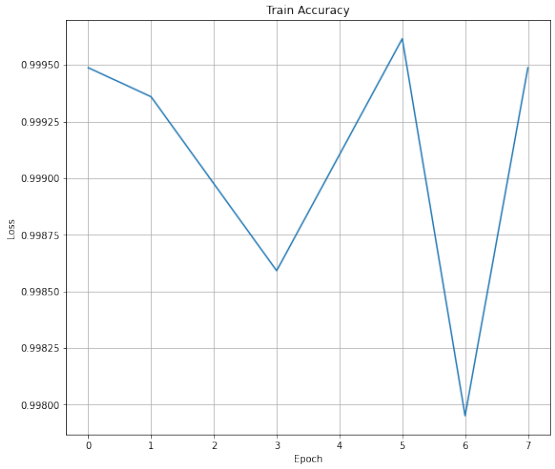
```
        Epoch 6, Validation Loss: 0.4326, Validation Accuracy: 92.0507 %
Epoch 7, Train Loss: 0.0029, Train Accuracy: 99.8976 %
         ---------------------------------------
        Predicted : tensor([ 3,  5, 67, 65], device='cuda:0')
        Result : tensor([ 3,  5,  9, 65], device='cuda:0')
        TOTAL (correct/total): 797.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.4154, Validation Accuracy: 91.8203 %

 ----------------------------------------
```

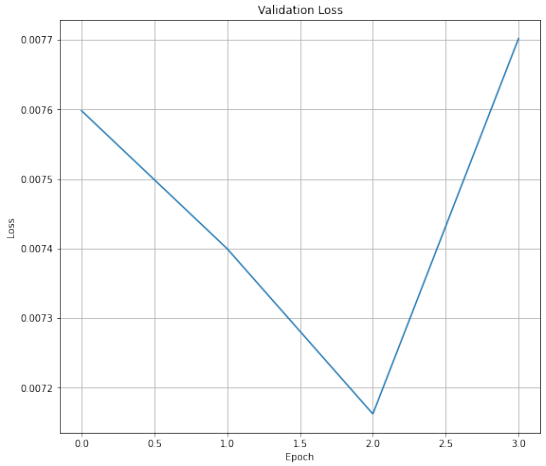


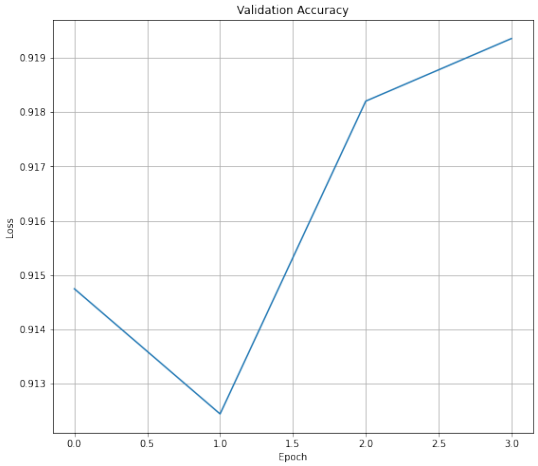

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:32:46 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0013, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([49, 64,  0, 94], device='cuda:0')
        Result : tensor([49, 64,  0, 94], device='cuda:0')
        TOTAL (correct/total): 794.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4179, Validation Accuracy: 91.4747 %
Epoch 3, Train Loss: 0.0041, Train Accuracy: 99.8976 %
         ----------------------------------------
        Predicted : tensor([62, 53, 38,  1], device='cuda:0')
        Result : tensor([62, 53, 38,  1], device='cuda:0')
        TOTAL (correct/total): 792.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4070, Validation Accuracy: 91.2442 %
Epoch 5, Train Loss: 0.0027, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([8, 5, 0, 3], device='cuda:0')
        Result : tensor([8, 5, 0, 3], device='cuda:0')
        TOTAL (correct/total): 797.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.3939, Validation Accuracy: 91.8203 %
Epoch 7, Train Loss: 0.0061, Train Accuracy: 99.7951 %
         ----------------------------------------
        Predicted : tensor([ 5, 66, 50, 55], device='cuda:0')
        Result : tensor([ 5, 66, 50, 79], device='cuda:0')
        TOTAL (correct/total): 798.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4236, Validation Accuracy: 91.9355 %

 ----------------------------------------
```



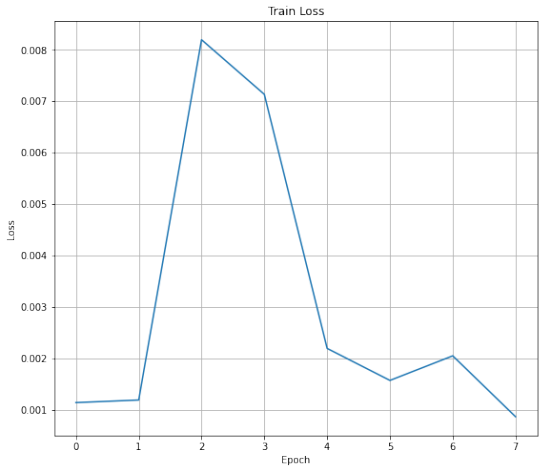


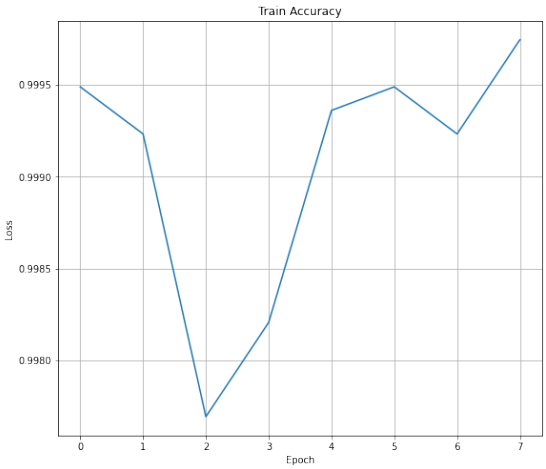


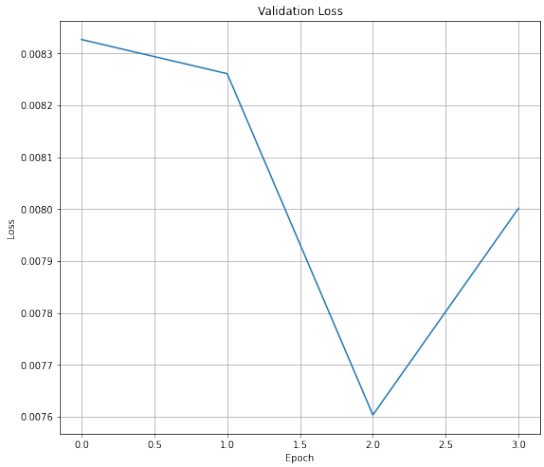


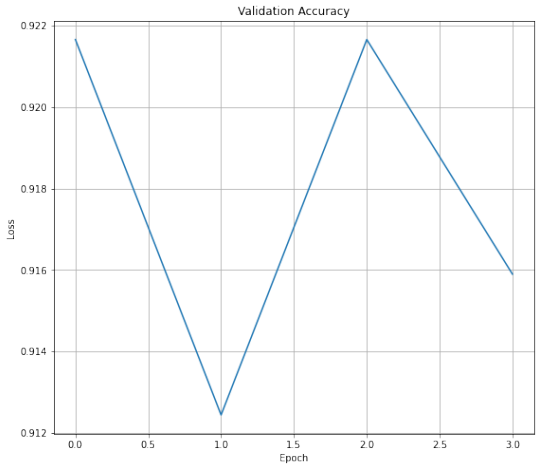

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:38:13 ago. (Use '!kill␣
  ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0011, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([ 99, 100,  21,   1], device='cuda:0')
        Result : tensor([99, 17, 21,  1], device='cuda:0')
```

```
        TOTAL (correct/total): 800.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4580, Validation Accuracy: 92.1659 %
Epoch 3, Train Loss: 0.0082, Train Accuracy: 99.7695 %
         ----------------------------------------
        Predicted : tensor([39, 94,  1,  3], device='cuda:0')
        Result : tensor([39, 94,  0,  3], device='cuda:0')
        TOTAL (correct/total): 792.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4544, Validation Accuracy: 91.2442 %
Epoch 5, Train Loss: 0.0022, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([ 1, 37,  1, 29], device='cuda:0')
        Result : tensor([ 1, 37,  1, 29], device='cuda:0')
        TOTAL (correct/total): 800.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.4182, Validation Accuracy: 92.1659 %
Epoch 7, Train Loss: 0.0021, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([ 3, 24, 65,  5], device='cuda:0')
        Result : tensor([ 3, 26, 65,  5], device='cuda:0')
        TOTAL (correct/total): 795.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4401, Validation Accuracy: 91.5899 %

 ----------------------------------------
```



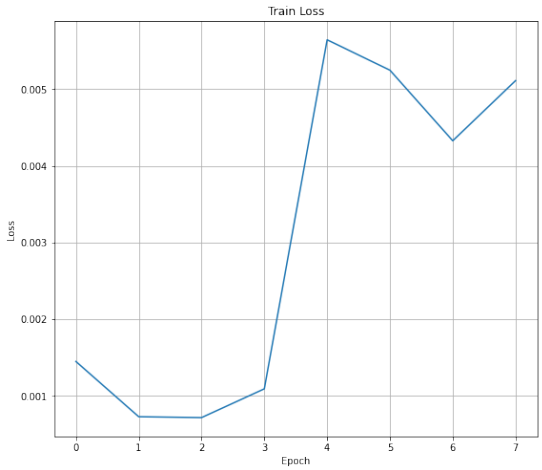


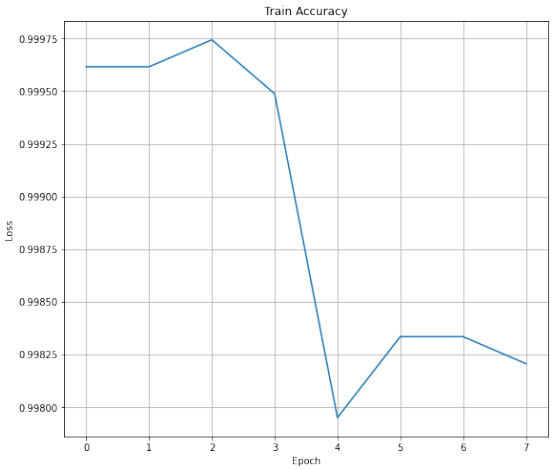


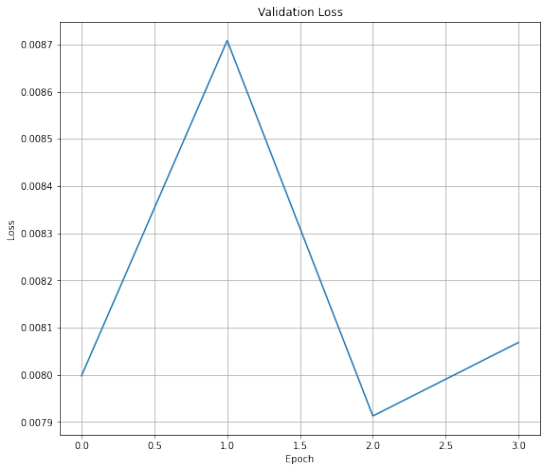


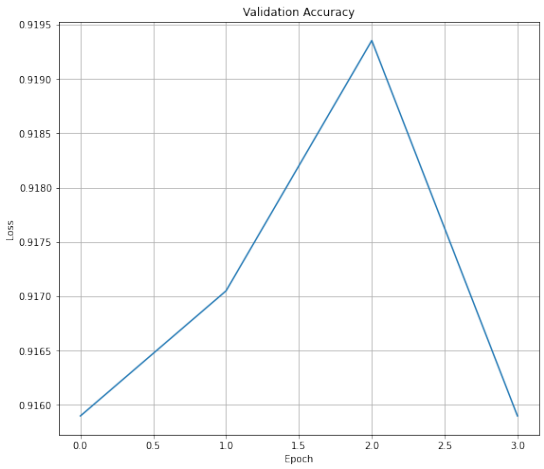

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:43:41 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0014, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([47,  3, 90, 22], device='cuda:0')
        Result : tensor([47,  3, 90, 22], device='cuda:0')
        TOTAL (correct/total): 795.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.4399, Validation Accuracy: 91.5899 %
Epoch 3, Train Loss: 0.0007, Train Accuracy: 99.9744 %
         ----------------------------------------
        Predicted : tensor([ 1, 21, 47,  0], device='cuda:0')
        Result : tensor([ 1, 21, 47,  0], device='cuda:0')
        TOTAL (correct/total): 796.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4790, Validation Accuracy: 91.7051 %
Epoch 5, Train Loss: 0.0056, Train Accuracy: 99.7951 %
         ----------------------------------------
        Predicted : tensor([91, 79, 58, 58], device='cuda:0')
        Result : tensor([91, 79, 58, 58], device='cuda:0')
        TOTAL (correct/total): 798.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 0.4352, Validation Accuracy: 91.9355 %
Epoch 7, Train Loss: 0.0043, Train Accuracy: 99.8335 %
         ---------------------------------------
        Predicted : tensor([ 3, 52, 65, 52], device='cuda:0')
        Result : tensor([ 3, 52, 65, 52], device='cuda:0')
        TOTAL (correct/total): 795.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.4438, Validation Accuracy: 91.5899 %

 ---------------------------------------
```



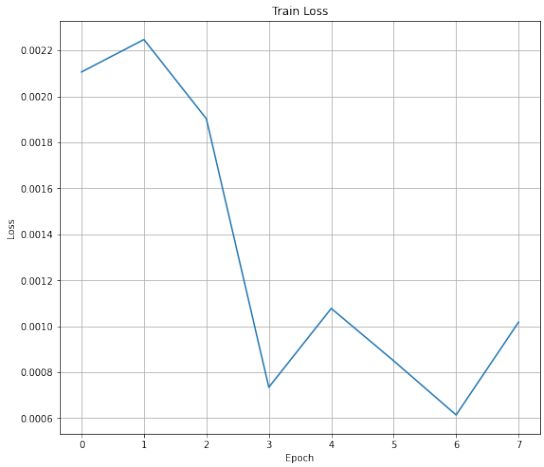


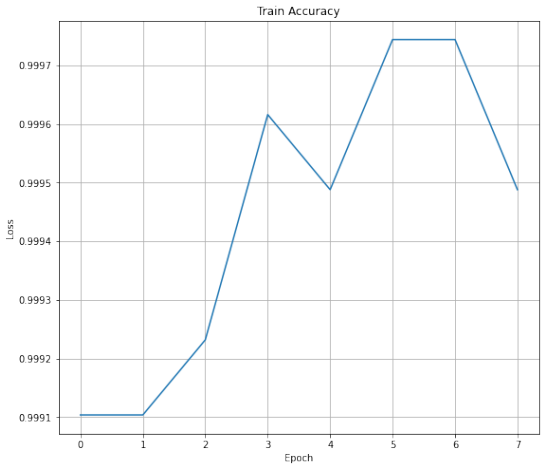


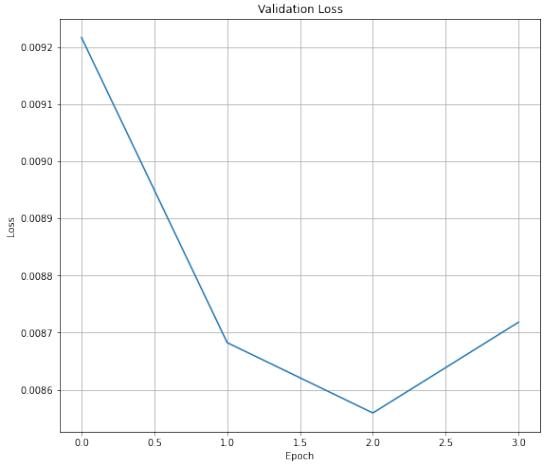


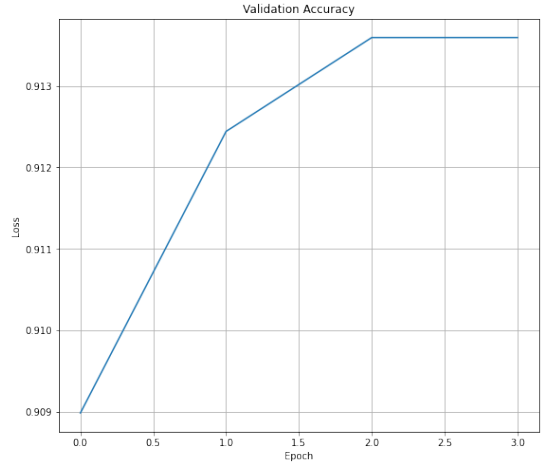

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 1:49:08 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0021, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([ 9, 76, 34, 73], device='cuda:0')
        Result : tensor([ 9, 76, 34, 68], device='cuda:0')
        TOTAL (correct/total): 789.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.5069, Validation Accuracy: 90.8986 %
Epoch 3, Train Loss: 0.0019, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([92, 86, 23,  0], device='cuda:0')
        Result : tensor([92, 86, 23,  0], device='cuda:0')
        TOTAL (correct/total): 792.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.4775, Validation Accuracy: 91.2442 %
Epoch 5, Train Loss: 0.0011, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([94, 16,  1, 75], device='cuda:0')
        Result : tensor([94, 16,  1, 75], device='cuda:0')
        TOTAL (correct/total): 793.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.4708, Validation Accuracy: 91.3594 %
Epoch 7, Train Loss: 0.0006, Train Accuracy: 99.9744 %
         ----------------------------------------
        Predicted : tensor([86,  0,  1, 96], device='cuda:0')
        Result : tensor([86,  0,  1, 96], device='cuda:0')
        TOTAL (correct/total): 793.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.4795, Validation Accuracy: 91.3594 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 3547), started 1:54:33 ago. (Use '!kill␣
↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

```
La moyenne des accuracy: 363.7558 %
```

7.3 Pour le modèle squeezenet1_0 avec K = 10

[ ]:
```
model_squeezenet1_0 = adapt_pretrained_model("squeezenet1_0")
loss_fn = nn.CrossEntropyLoss()
optimiseur_squeezenet1_0 = torch.optim.SGD(model_squeezenet1_0.parameters(),␣
↪lr=0.001, momentum=0.9)
```

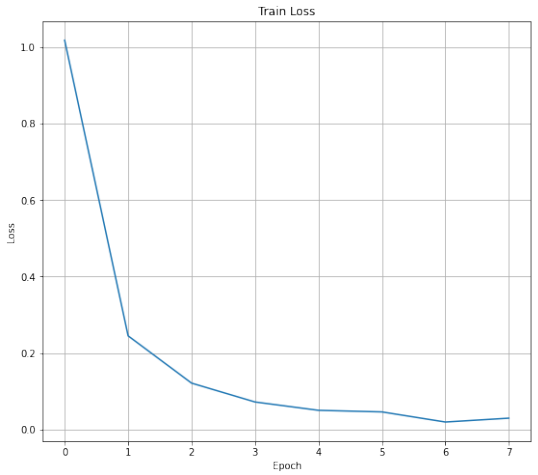
```
mean_squeezenet1_0 =␣
 ↪boucle_de_validation_croisee_pour_k_iteration(model_squeezenet1_0,␣
 ↪train_dataloader, test_dataloader, loss_fn, optimiseur_squeezenet1_0,␣
 ↪epochs, typeTrain="squeezenet1_0")
```

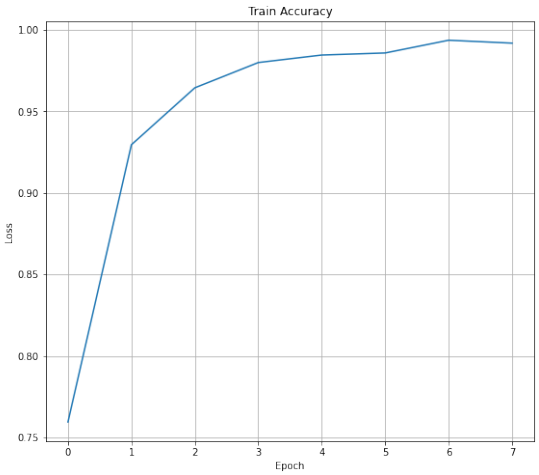
7.4 Pour le modèle vgg16 avec K = 10

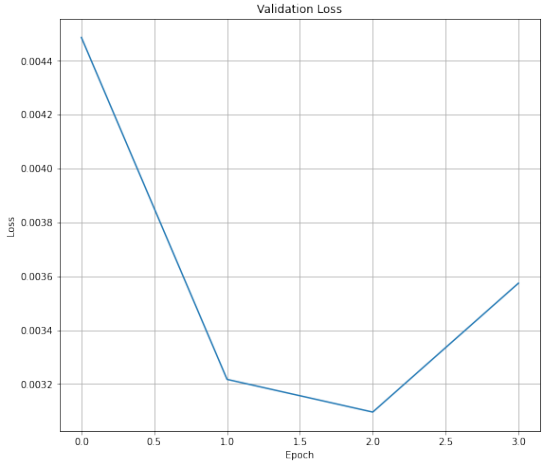
[13]:
```
model_vgg16 = adapt_pretrained_model("vgg16")
loss_fn = nn.CrossEntropyLoss()
optimiseur_vgg16 = torch.optim.SGD(model_vgg16.parameters(), lr=0.001,␣
 ↪momentum=0.9)

mean_vgg16 = boucle_de_validation_croisee_pour_k_iteration(model_vgg16,␣
 ↪train_dataloader, test_dataloader, loss_fn, optimiseur_vgg16, epochs,␣
 ↪typeTrain="vgg16")
```

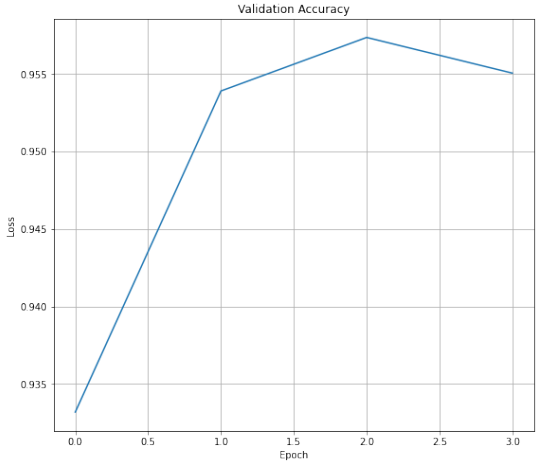
```
Downloading: "https://download.pytorch.org/models/vgg16-397923af.pth" to
/root/.cache/torch/hub/checkpoints/vgg16-397923af.pth

  0%|          | 0.00/528M [00:00<?, ?B/s]

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 1.0185, Train Accuracy: 75.9380 %
         ----------------------------------------
        Predicted : tensor([84, 46, 50,  5], device='cuda:0')
        Result : tensor([84, 46, 50,  5], device='cuda:0')
        TOTAL (correct/total): 810.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.2468, Validation Accuracy: 93.3180 %
Epoch 3, Train Loss: 0.1211, Train Accuracy: 96.4528 %
         ----------------------------------------
        Predicted : tensor([53,  5, 12,  0], device='cuda:0')
        Result : tensor([53,  5, 12,  0], device='cuda:0')
        TOTAL (correct/total): 828.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1769, Validation Accuracy: 95.3917 %
Epoch 5, Train Loss: 0.0499, Train Accuracy: 98.4633 %
         ----------------------------------------
        Predicted : tensor([22, 58, 23, 51], device='cuda:0')
        Result : tensor([22, 58, 23, 51], device='cuda:0')
        TOTAL (correct/total): 831.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1703, Validation Accuracy: 95.7373 %
```

```
Epoch 7, Train Loss: 0.0193, Train Accuracy: 99.3725 %
         ----------------------------------------
        Predicted : tensor([3, 2, 1, 3], device='cuda:0')
        Result : tensor([3, 2, 1, 3], device='cuda:0')
        TOTAL (correct/total): 829.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1966, Validation Accuracy: 95.5069 %

 ----------------------------------------
```



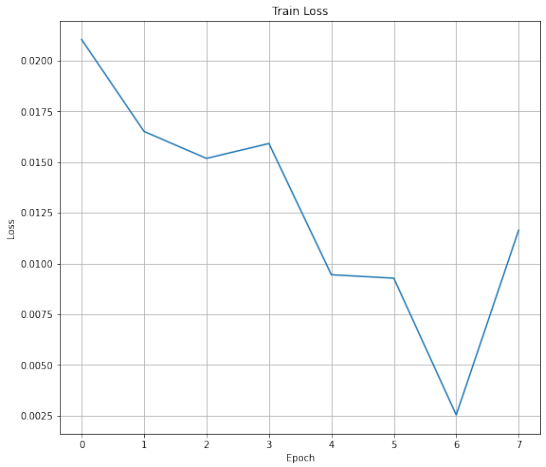


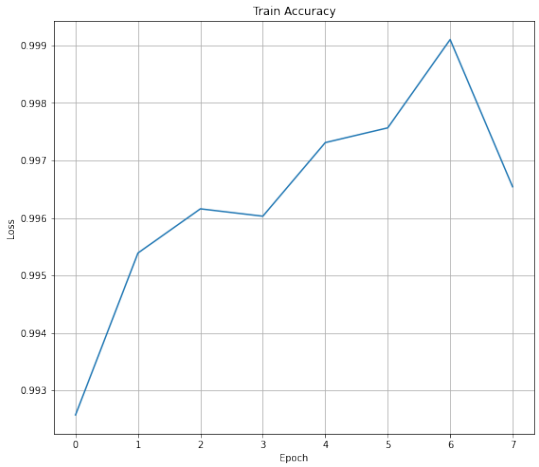


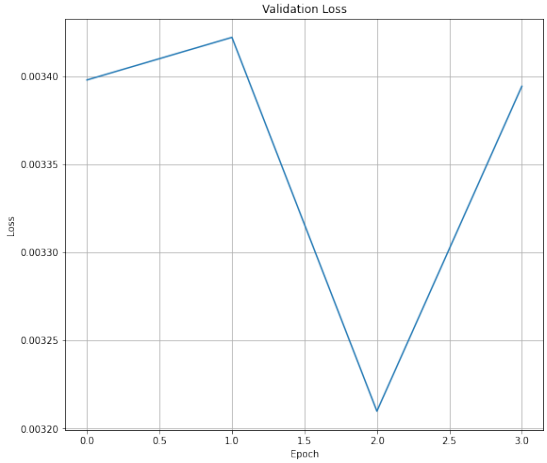


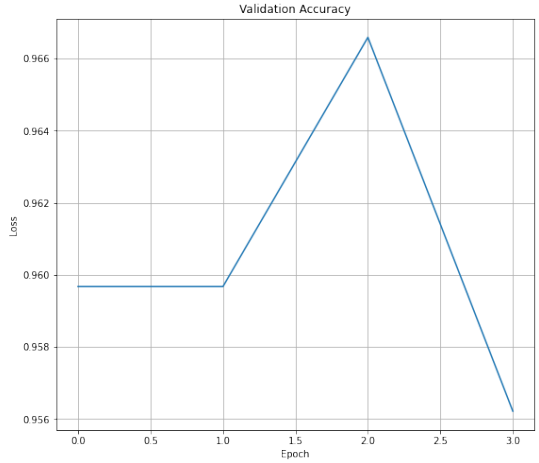

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 2:21:58 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0210, Train Accuracy: 99.2573 %
         ----------------------------------------
        Predicted : tensor([88, 69, 70, 84], device='cuda:0')
        Result : tensor([88, 69, 70, 84], device='cuda:0')
        TOTAL (correct/total): 833.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1869, Validation Accuracy: 95.9677 %
Epoch 3, Train Loss: 0.0152, Train Accuracy: 99.6158 %
         ----------------------------------------
        Predicted : tensor([95, 80, 98, 62], device='cuda:0')
        Result : tensor([95, 80, 98, 62], device='cuda:0')
        TOTAL (correct/total): 833.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1882, Validation Accuracy: 95.9677 %
Epoch 5, Train Loss: 0.0094, Train Accuracy: 99.7311 %
         ----------------------------------------
        Predicted : tensor([27, 46, 46,  3], device='cuda:0')
        Result : tensor([59, 46, 46,  3], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1765, Validation Accuracy: 96.6590 %
Epoch 7, Train Loss: 0.0025, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([60, 84, 45,  3], device='cuda:0')
        Result : tensor([60, 84, 45,  3], device='cuda:0')
        TOTAL (correct/total): 830.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1867, Validation Accuracy: 95.6221 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

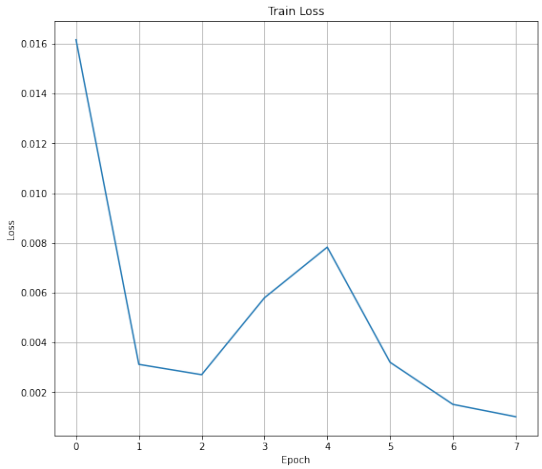
```
Reusing TensorBoard on port 6006 (pid 3547), started 2:41:50 ago. (Use '!kill␣
↪3547' to kill it.)
```

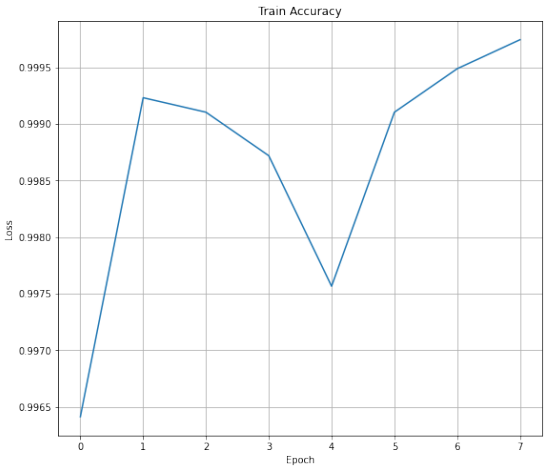
```
<IPython.core.display.Javascript object>
```

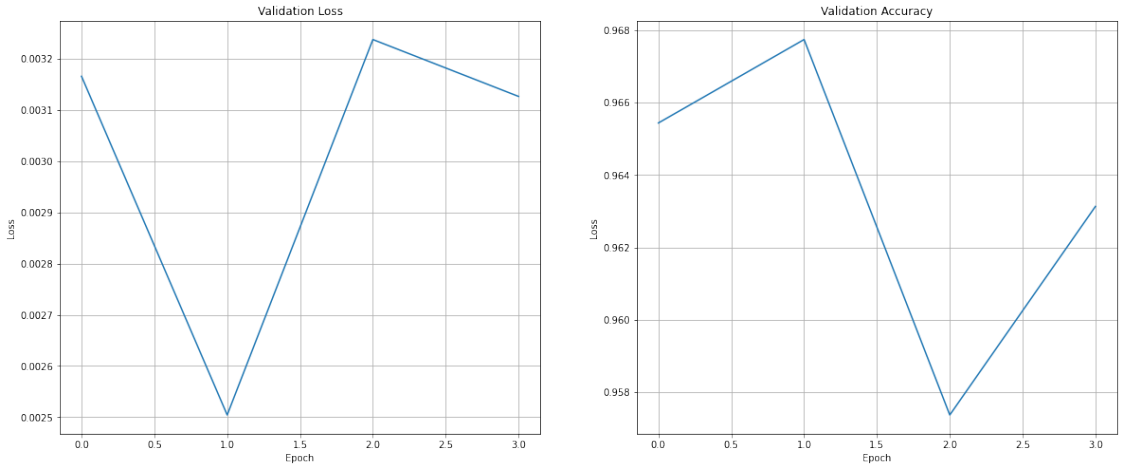
```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0
```

```
 ----------------------------------------
Epoch 1, Train Loss: 0.0162, Train Accuracy: 99.6414 %
         ----------------------------------------
        Predicted : tensor([91, 21, 36, 81], device='cuda:0')
        Result : tensor([91, 21, 36, 81], device='cuda:0')
```

```
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1741, Validation Accuracy: 96.5438 %
Epoch 3, Train Loss: 0.0027, Train Accuracy: 99.9104 %
         ----------------------------------------
        Predicted : tensor([ 8, 70, 38, 29], device='cuda:0')
        Result : tensor([ 8, 70, 38, 29], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1377, Validation Accuracy: 96.7742 %
Epoch 5, Train Loss: 0.0078, Train Accuracy: 99.7567 %
         ----------------------------------------
        Predicted : tensor([21,  5, 23, 21], device='cuda:0')
        Result : tensor([21,  5, 23, 21], device='cuda:0')
        TOTAL (correct/total): 831.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1781, Validation Accuracy: 95.7373 %
Epoch 7, Train Loss: 0.0015, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([ 3,  3, 58,  5], device='cuda:0')
        Result : tensor([ 3,  3, 58,  5], device='cuda:0')
        TOTAL (correct/total): 836.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1720, Validation Accuracy: 96.3134 %

 ----------------------------------------
```

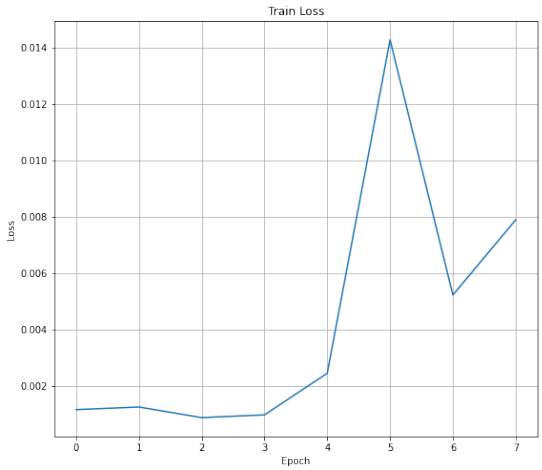


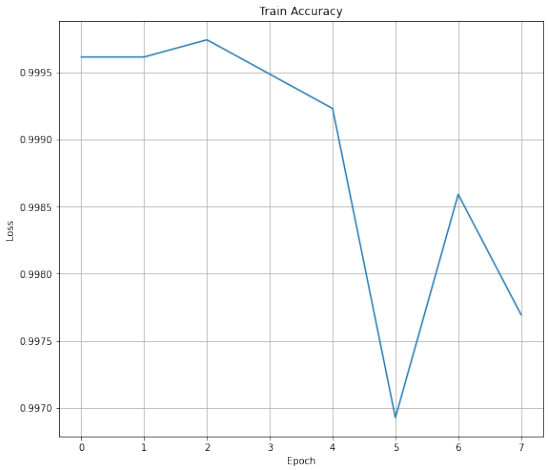


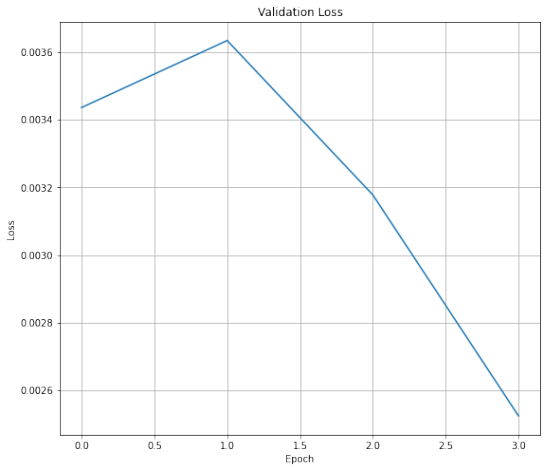


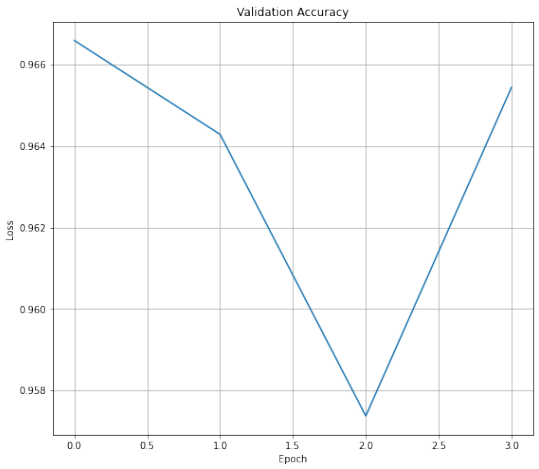

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 3:01:43 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0011, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([88, 93, 95,  5], device='cuda:0')
        Result : tensor([88, 93, 60,  5], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1890, Validation Accuracy: 96.6590 %
Epoch 3, Train Loss: 0.0009, Train Accuracy: 99.9744 %
         ----------------------------------------
        Predicted : tensor([66,  0,  3, 90], device='cuda:0')
        Result : tensor([66,  0,  3, 90], device='cuda:0')
        TOTAL (correct/total): 837.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1998, Validation Accuracy: 96.4286 %
Epoch 5, Train Loss: 0.0024, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([ 3,  3, 95,  5], device='cuda:0')
        Result : tensor([ 3,  3, 60,  5], device='cuda:0')
        TOTAL (correct/total): 831.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 0.1748, Validation Accuracy: 95.7373 %
Epoch 7, Train Loss: 0.0052, Train Accuracy: 99.8591 %
         ---------------------------------------
        Predicted : tensor([43, 31,  8,  6], device='cuda:0')
        Result : tensor([43, 31,  8,  6], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.1389, Validation Accuracy: 96.5438 %

 ----------------------------------------
```



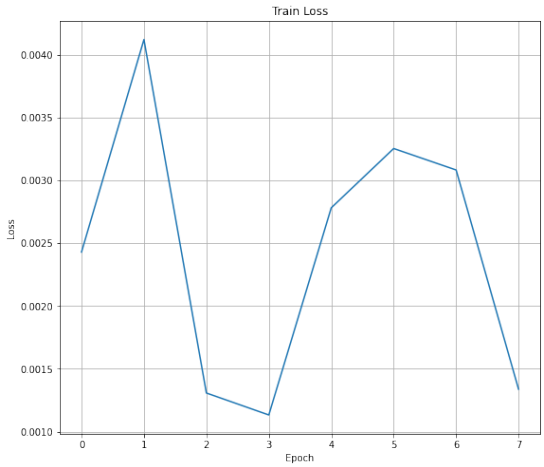


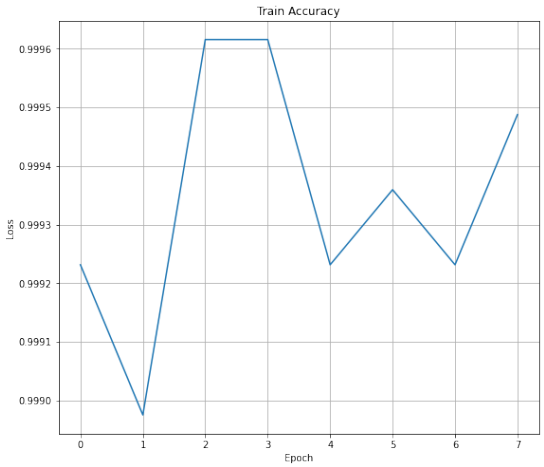


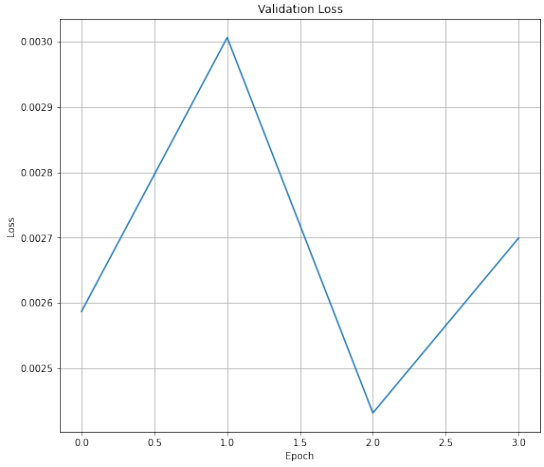


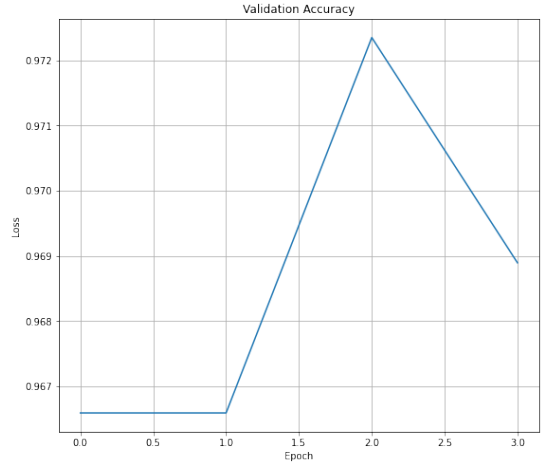

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 3:21:35 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0024, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([48,  0, 84, 36], device='cuda:0')
        Result : tensor([48,  0, 84, 36], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1423, Validation Accuracy: 96.6590 %
Epoch 3, Train Loss: 0.0013, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([ 94,   5, 100,  24], device='cuda:0')
        Result : tensor([ 94,   5, 100,  10], device='cuda:0')
        TOTAL (correct/total): 839.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1654, Validation Accuracy: 96.6590 %
Epoch 5, Train Loss: 0.0028, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([65,  8,  0,  5], device='cuda:0')
        Result : tensor([65,  8,  0,  5], device='cuda:0')
        TOTAL (correct/total): 844.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1337, Validation Accuracy: 97.2350 %
Epoch 7, Train Loss: 0.0031, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([38,  3, 37, 17], device='cuda:0')
        Result : tensor([48,  3, 37, 17], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1485, Validation Accuracy: 96.8894 %

 ----------------------------------------
```



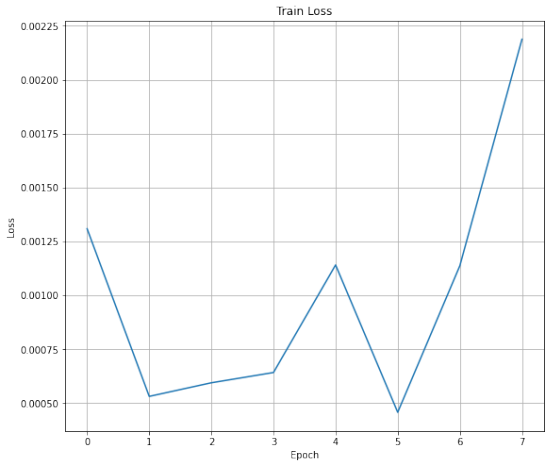


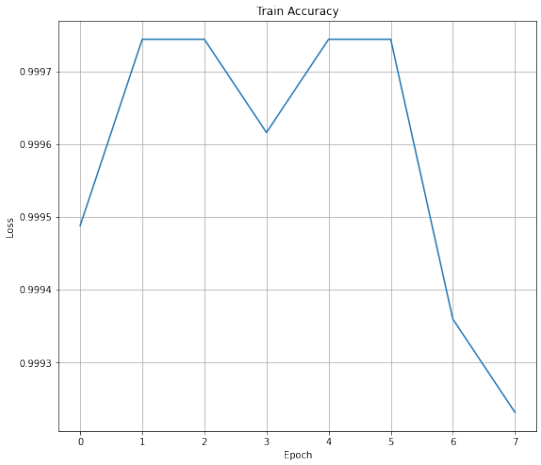


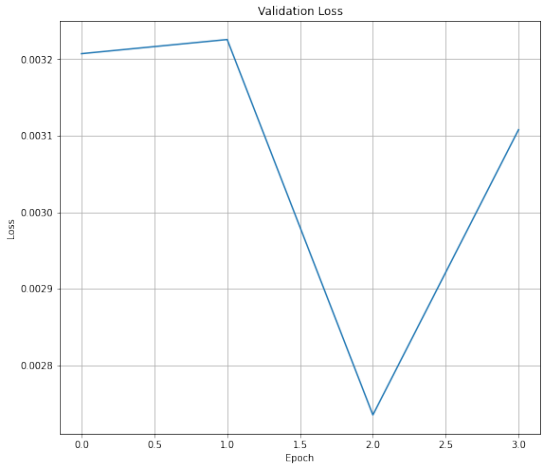


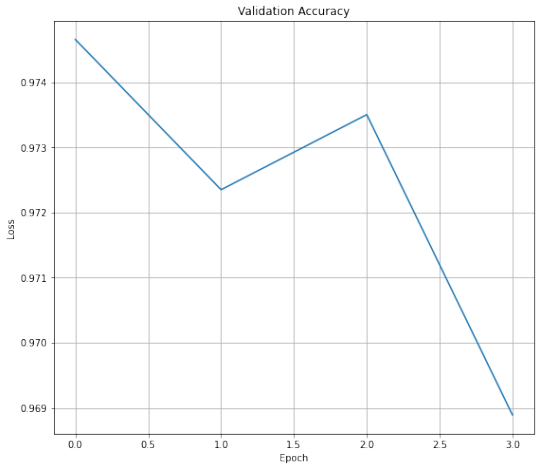

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 3:41:24 ago. (Use '!kill␣
  ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0013, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([61,  0, 95, 79], device='cuda:0')
        Result : tensor([61,  0, 60, 79], device='cuda:0')
```

```
        TOTAL (correct/total): 846.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1764, Validation Accuracy: 97.4654 %
Epoch 3, Train Loss: 0.0006, Train Accuracy: 99.9744 %
         ----------------------------------------
        Predicted : tensor([19, 82,  0, 46], device='cuda:0')
        Result : tensor([19, 30,  0, 46], device='cuda:0')
        TOTAL (correct/total): 844.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1774, Validation Accuracy: 97.2350 %
Epoch 5, Train Loss: 0.0011, Train Accuracy: 99.9744 %
         ----------------------------------------
        Predicted : tensor([ 3,  3, 82, 17], device='cuda:0')
        Result : tensor([ 3,  3, 82, 17], device='cuda:0')
        TOTAL (correct/total): 845.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1504, Validation Accuracy: 97.3502 %
Epoch 7, Train Loss: 0.0011, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([47, 12,  5,  0], device='cuda:0')
        Result : tensor([47, 12,  5,  0], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1709, Validation Accuracy: 96.8894 %

 ----------------------------------------
```



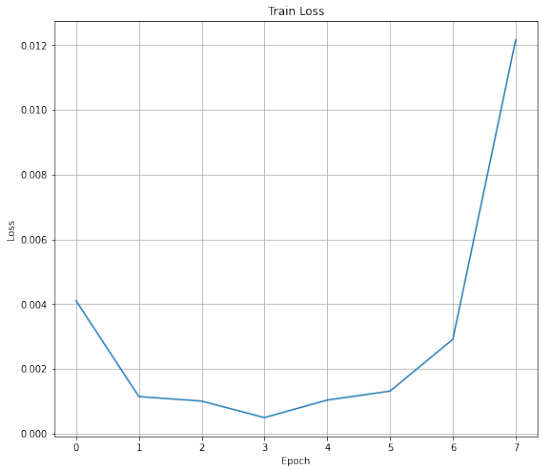


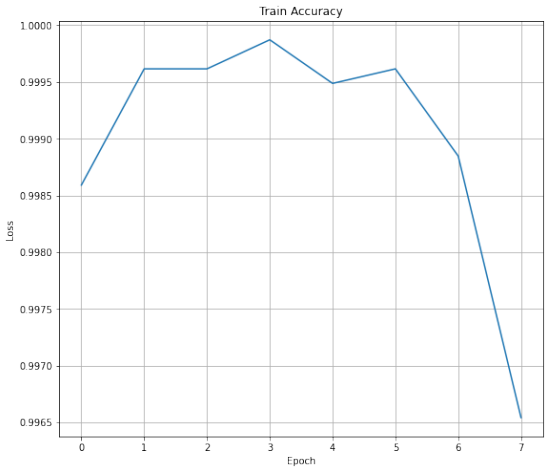


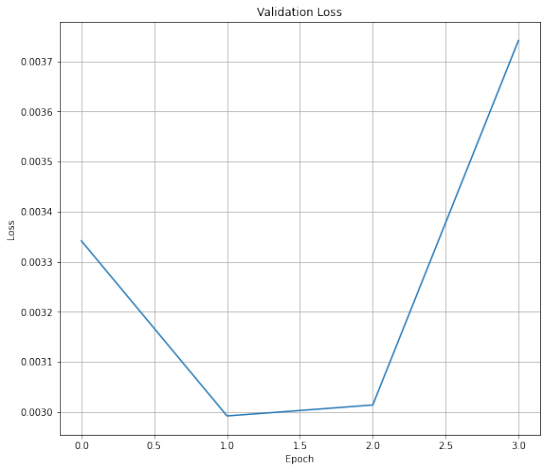


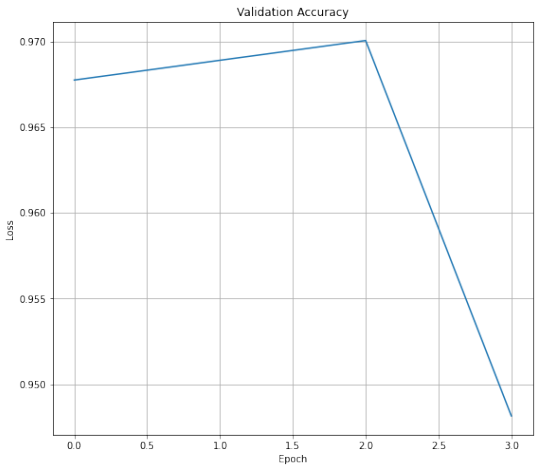

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 4:01:15 ago. (Use '!kill␣
 ↪3547' to kill it.)

<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0041, Train Accuracy: 99.8591 %
         ----------------------------------------
        Predicted : tensor([ 5, 94, 52, 81], device='cuda:0')
        Result : tensor([ 5, 94, 52, 81], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1838, Validation Accuracy: 96.7742 %
Epoch 3, Train Loss: 0.0010, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([91, 76, 85, 32], device='cuda:0')
        Result : tensor([91, 76, 85, 32], device='cuda:0')
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1646, Validation Accuracy: 96.8894 %
Epoch 5, Train Loss: 0.0010, Train Accuracy: 99.9488 %
         ----------------------------------------
        Predicted : tensor([66,  3, 71,  5], device='cuda:0')
        Result : tensor([66,  3, 71,  5], device='cuda:0')
        TOTAL (correct/total): 842.0 / 868.0
         ----------------------------------------
```

```
        Epoch 6, Validation Loss: 0.1658, Validation Accuracy: 97.0046 %
Epoch 7, Train Loss: 0.0029, Train Accuracy: 99.8847 %
         ----------------------------------------
        Predicted : tensor([84, 35, 13,  5], device='cuda:0')
        Result : tensor([84, 35, 13,  5], device='cuda:0')
        TOTAL (correct/total): 823.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.2058, Validation Accuracy: 94.8157 %

 ----------------------------------------
```



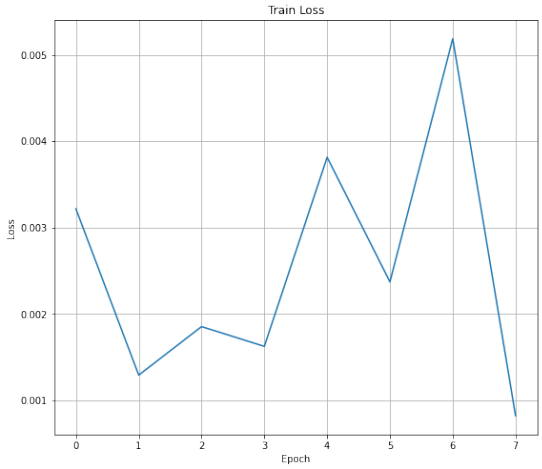


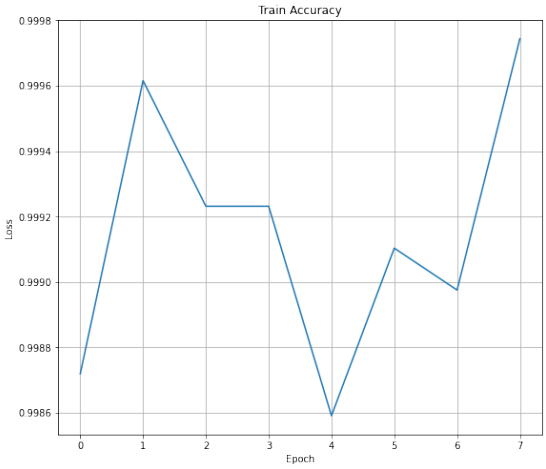


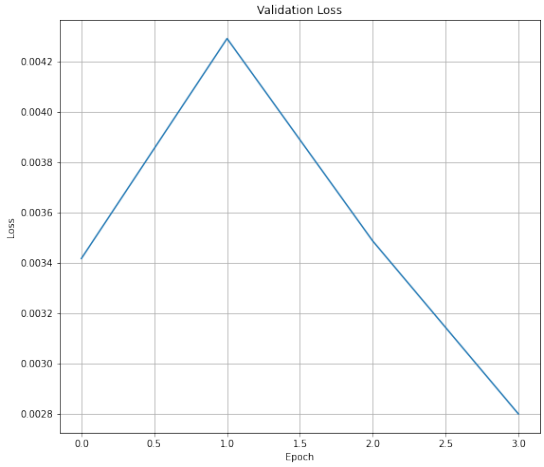


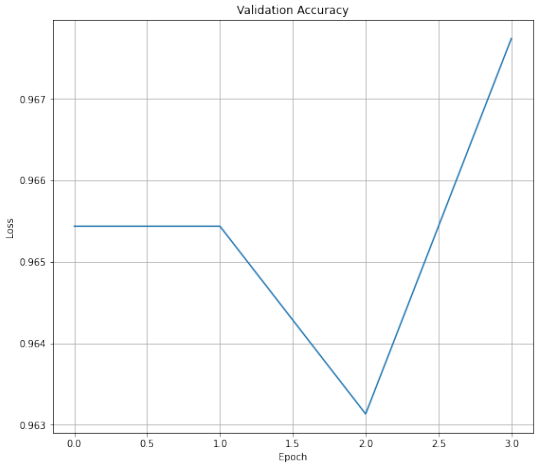

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 4:21:04 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>

La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0

 ----------------------------------------
Epoch 1, Train Loss: 0.0032, Train Accuracy: 99.8719 %
         ----------------------------------------
        Predicted : tensor([54, 79, 76, 73], device='cuda:0')
        Result : tensor([54, 79, 76, 73], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1880, Validation Accuracy: 96.5438 %
Epoch 3, Train Loss: 0.0019, Train Accuracy: 99.9232 %
         ----------------------------------------
        Predicted : tensor([31, 19, 12, 50], device='cuda:0')
        Result : tensor([31, 19, 12, 67], device='cuda:0')
        TOTAL (correct/total): 838.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.2360, Validation Accuracy: 96.5438 %
Epoch 5, Train Loss: 0.0038, Train Accuracy: 99.8591 %
         ----------------------------------------
        Predicted : tensor([57, 27,  3, 70], device='cuda:0')
        Result : tensor([57, 27,  3, 70], device='cuda:0')
        TOTAL (correct/total): 836.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1918, Validation Accuracy: 96.3134 %
Epoch 7, Train Loss: 0.0052, Train Accuracy: 99.8976 %
         ----------------------------------------
        Predicted : tensor([62, 22,  1, 94], device='cuda:0')
        Result : tensor([62, 22,  1, 94], device='cuda:0')
        TOTAL (correct/total): 840.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1540, Validation Accuracy: 96.7742 %

 ----------------------------------------
```










```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

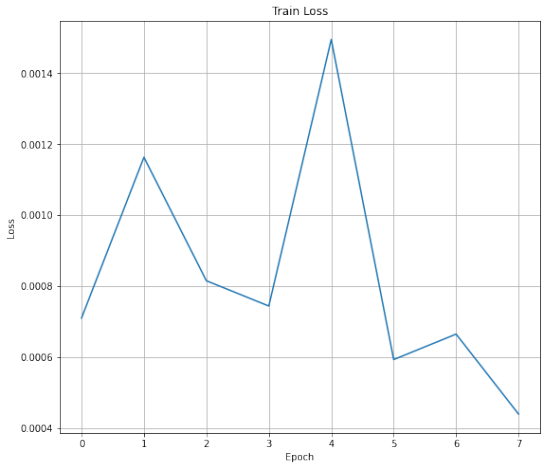
```
Reusing TensorBoard on port 6006 (pid 3547), started 4:40:55 ago. (Use '!kill␣
  ↪3547' to kill it.)
```

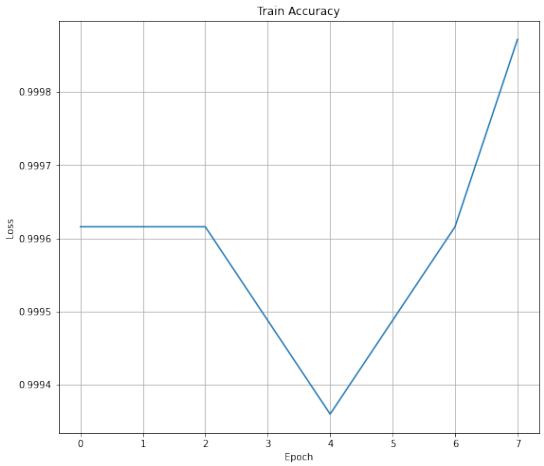
```
<IPython.core.display.Javascript object>
```

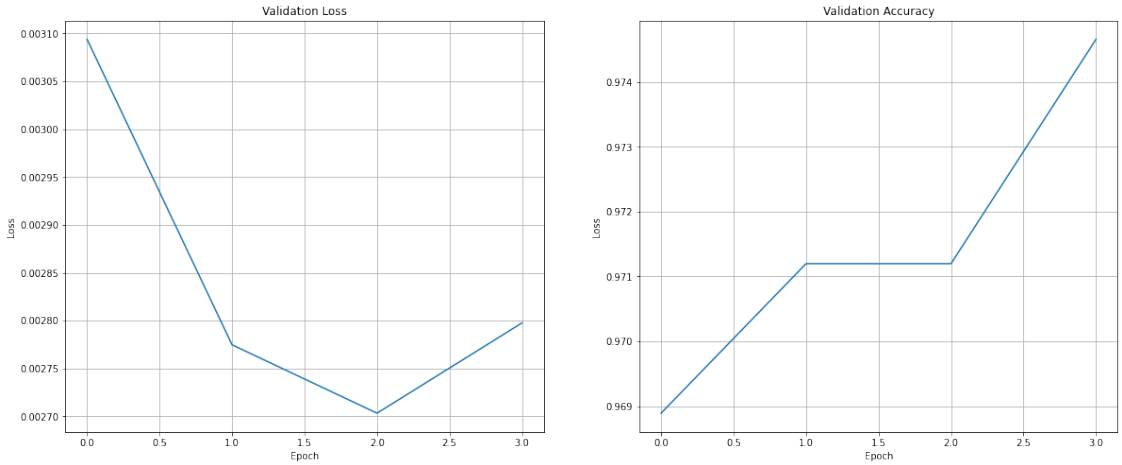
```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0
```

```
 ----------------------------------------
Epoch 1, Train Loss: 0.0007, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([86,  1,  5,  5], device='cuda:0')
        Result : tensor([86,  1,  5,  5], device='cuda:0')
```

```
        TOTAL (correct/total): 841.0 / 868.0
         ----------------------------------------
        Epoch 2, Validation Loss: 0.1702, Validation Accuracy: 96.8894 %
Epoch 3, Train Loss: 0.0008, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([39, 52,  0, 86], device='cuda:0')
        Result : tensor([39, 52,  0, 86], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         ----------------------------------------
        Epoch 4, Validation Loss: 0.1526, Validation Accuracy: 97.1198 %
Epoch 5, Train Loss: 0.0015, Train Accuracy: 99.9360 %
         ----------------------------------------
        Predicted : tensor([81, 93, 57, 65], device='cuda:0')
        Result : tensor([81, 93, 57, 65], device='cuda:0')
        TOTAL (correct/total): 843.0 / 868.0
         ----------------------------------------
        Epoch 6, Validation Loss: 0.1487, Validation Accuracy: 97.1198 %
Epoch 7, Train Loss: 0.0007, Train Accuracy: 99.9616 %
         ----------------------------------------
        Predicted : tensor([  5,   5, 100,  79], device='cuda:0')
        Result : tensor([ 5,  5, 66, 79], device='cuda:0')
        TOTAL (correct/total): 846.0 / 868.0
         ----------------------------------------
        Epoch 8, Validation Loss: 0.1539, Validation Accuracy: 97.4654 %

 ----------------------------------------
```








```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

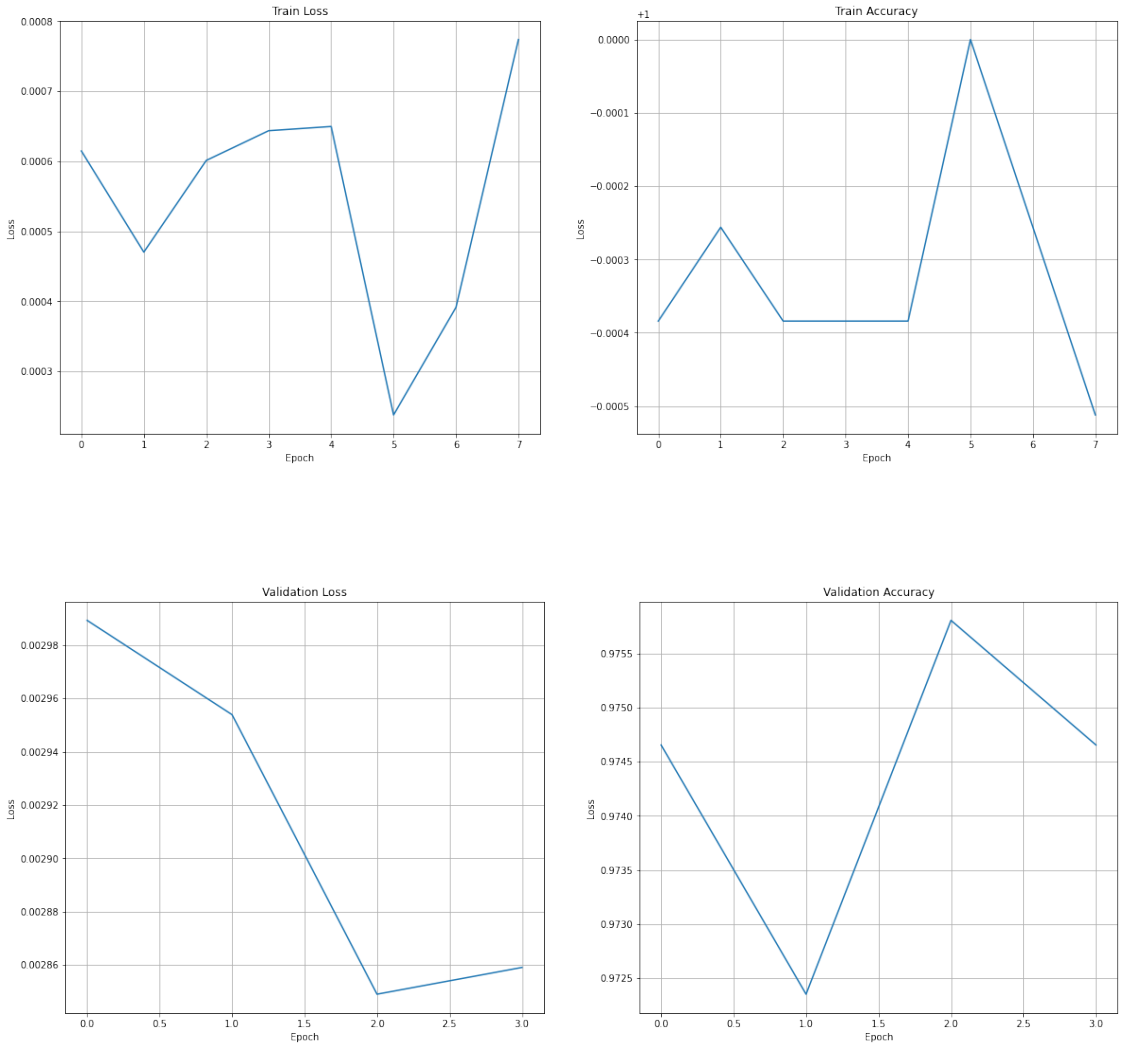
```
Reusing TensorBoard on port 6006 (pid 3547), started 5:00:47 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

```
La liste des fichiers du dossier '/content/' sur colab : ['.config',
'101_ObjectCategories', '__MACOSX', 'caltech-101.zip', 'sample_data']
Device is : cuda:0
```

```
 ---------------------------------------
Epoch 1, Train Loss: 0.0006, Train Accuracy: 99.9616 %
         ---------------------------------------
        Predicted : tensor([36,  1, 19, 94], device='cuda:0')
        Result : tensor([36,  1, 19, 94], device='cuda:0')
        TOTAL (correct/total): 846.0 / 868.0
         ---------------------------------------
        Epoch 2, Validation Loss: 0.1644, Validation Accuracy: 97.4654 %
Epoch 3, Train Loss: 0.0006, Train Accuracy: 99.9616 %
         ---------------------------------------
        Predicted : tensor([20,  0,  0,  3], device='cuda:0')
        Result : tensor([20,  0,  0,  3], device='cuda:0')
        TOTAL (correct/total): 844.0 / 868.0
         ---------------------------------------
        Epoch 4, Validation Loss: 0.1625, Validation Accuracy: 97.2350 %
Epoch 5, Train Loss: 0.0006, Train Accuracy: 99.9616 %
         ---------------------------------------
        Predicted : tensor([98, 21, 72, 87], device='cuda:0')
        Result : tensor([98, 21, 72, 87], device='cuda:0')
        TOTAL (correct/total): 847.0 / 868.0
         ---------------------------------------
```

```
        Epoch 6, Validation Loss: 0.1567, Validation Accuracy: 97.5806 %
Epoch 7, Train Loss: 0.0004, Train Accuracy: 99.9744 %
         ---------------------------------------
        Predicted : tensor([72,  5, 27, 71], device='cuda:0')
        Result : tensor([72,  5, 27, 71], device='cuda:0')
        TOTAL (correct/total): 846.0 / 868.0
         ---------------------------------------
        Epoch 8, Validation Loss: 0.1572, Validation Accuracy: 97.4654 %

 ----------------------------------------
```




```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard

Reusing TensorBoard on port 6006 (pid 3547), started 5:20:39 ago. (Use '!kill␣
 ↪3547' to kill it.)
```

```
<IPython.core.display.Javascript object>
```

```
La moyenne des accuracy: 386.1290 %
```

7.5 Pour le modèle densenet161 avec K = 10

[ ]:
```
model_densenet161 = adapt_pretrained_model("densenet161")
loss_fn = nn.CrossEntropyLoss()
optimiseur_densenet161 = torch.optim.SGD(model_densenet161.parameters(), lr=0.
↪001, momentum=0.9)

mean_densenet161 =␣
↪boucle_de_validation_croisee_pour_k_iteration(model_densenet161,␣
↪train_dataloader, test_dataloader, loss_fn, optimiseur_densenet161, epochs,␣
↪typeTrain="densenet161")
```

7.6 Pour le modèle inception_v3 avec K = 10

[ ]:
```
model_inception_v3 = adapt_pretrained_model("inception_v3")
loss_fn = nn.CrossEntropyLoss()
optimiseur_inception_v3 = torch.optim.SGD(model_inception_v3.parameters(), lr=0.
↪001, momentum=0.9)

mean_inception_v3 =␣
↪boucle_de_validation_croisee_pour_k_iteration(model_inception_v3,␣
↪train_dataloader, test_dataloader, loss_fn, optimiseur_inception_v3, epochs,␣
↪typeTrain="inception_v3")
```

7.7 Comparaison des moyennes des modèles

[11]:
```
def compare_means_model(model_name_1, mean_model_1, model_name_2, mean_model_2):
    print("Comparaison entre les modèles : [", model_name_1, ",", mean_model_1,␣
↪"] VS [", model_name_2, ",", mean_model_2, "] ")
    if mean_model_1 < mean_model_2:
        print("\n_____\nLe␣
↪Modèle", model_name_1, "est le plus performant avec une accuracy moyenne de :
↪", mean_model_1, "!\n_____\n")
    else:
        print("\n_____\nLe␣
↪Modèle", model_name_2, "est le plus performant avec une accuracy moyenne de :
↪", mean_model_2, "!\n_____\n")
```

Pour : resnet18 VS alexnet

[12]:
```
compare_means_model("resnet18", mean_resnet18, "alexnet", mean_alexnet)
```

```
--------------------------------------------------
Le Modèle alexnet est le plus performant avec une accuracy moyenne de :
```

```
3.6375576036866355 !
--------------------------------------------------
```

Pour : squeezenet1_0 VS vgg16

[ ]:
```
compare_means_model("squeezenet1_0", mean_squeezenet1_0, "vgg16", mean_vgg16)
```

Pour : alexnet VS squeezenet1_0

[ ]:
```
compare_means_model("alexnet", mean_alexnet, "squeezenet1_0",␣
↪mean_squeezenet1_0)
```

Pour : resnet18 VS vgg16

[ ]:
```
compare_means_model("resnet18", mean_resnet18, "vgg16", mean_vgg16)
```

Pour : resnet18 VS densenet161

[ ]:
```
compare_means_model("resnet18", mean_resnet18, "densenet161", mean_densenet161)
```

7.7.1 Pour : densenet161 VS inception_v3

[ ]:
```
compare_means_model("densenet161", mean_densenet161, "inception_v3",␣
↪mean_inception_v3)
```