Lab 3: Gesture Recognition using Convolutional Neural Networks

In this lab you will train a convolutional neural network to make classifications on different hand gestures. By the end of the lab, you should be able to:

1. Load and split data for training, validation and testing
2. Train a Convolutional Neural Network
3. Apply transfer learning to improve your model

Note that for this lab we will not be providing you with any starter code. You should be able to take the code used in previous labs, tutorials and lectures and modify it accordingly to complete the tasks outlined below.

What to submit

Submit a PDF file containing all your code, outputs, and write-up from parts 1-5. You can produce a PDF of your Google Colab file by going to **File > Print** and then save as PDF. The Colab instructions has more information. Make sure to review the PDF submission to ensure that your answers are easy to read. Make sure that your text is not cut off at the margins.

Do not submit any other files produced by your code.

Include a link to your colab file in your submission.

Please use Google Colab to complete this assignment. If you want to use Jupyter Notebook, please complete the assignment and upload your Jupyter Notebook file to Google Colab for submission.

Colab Link

Include a link to your colab file here

Colab Link:
https://colab.research.google.com/drive/1oLJ2nBVeriGBzqZmRMsEv52iflyaFHMU?usp=sharing

Dataset

American Sign Language (ASL) is a complete, complex language that employs signs made by moving the hands combined with facial expressions and postures of the body. It is the primary language of many North Americans who are deaf and is one of several

communication options used by people who are deaf or hard-of-hearing. The hand gestures representing English alphabet are shown below. This lab focuses on classifying a subset of these hand gesture images using convolutional neural networks. Specifically, given an image of a hand showing one of the letters A-I, we want to detect which letter is being represented.

Part B. Building a CNN [50 pt]

For this lab, we are not going to give you any starter code. You will be writing a convolutional neural network from scratch. You are welcome to use any code from previous labs, lectures and tutorials. You should also write your own code.

You may use the PyTorch documentation freely. You might also find online tutorials helpful. However, all code that you submit must be your own.

Make sure that your code is vectorized, and does not contain obvious inefficiencies (for example, unecessary for loops, or unnecessary calls to unsqueeze()). Ensure enough comments are included in the code so that your TA can understand what you are doing. It is your responsibility to show that you understand what you write.

This is much more challenging and time-consuming than the previous labs. Make sure that you give yourself plenty of time by starting early.

1. Data Loading and Splitting [5 pt]

Download the anonymized data provided on Quercus. To allow you to get a heads start on this project we will provide you with sample data from previous years. Split the data into training, validation, and test sets.

Note: Data splitting is not as trivial in this lab. We want our test set to closely resemble the setting in which our model will be used. In particular, our test set should contain hands that are never seen in training!

Explain how you split the data, either by describing what you did, or by showing the code that you used. Justify your choice of splitting strategy. How many training, validation, and test images do you have?

For loading the data, you can use plt.imread as in Lab 1, or any other method that you choose. You may find torchvision.datasets.ImageFolder helpful. (see https://pytorch.org/docs/stable/torchvision/datasets.html?highlight=image%20folder#torchvision.datasets.ImageFolder)

In [1]:
```
import numpy as np
import time
import torch
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
import torchvision
from torch.utils.data.sampler import SubsetRandomSampler
import torchvision.transforms as transforms
import time
import os
```

```
import numpy as np
import torch

import torchvision
from torchvision import datasets, models, transforms
import matplotlib.pyplot as plt


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

```
Mounted at /content/gdrive
```

In [ ]:
```
cd /content/gdrive/MyDrive/ColabNotebooks/Lab3_Gestures_Summer
```

```
/content/gdrive/MyDrive/ColabNotebooks/Lab3_Gestures_Summer
```

In [2]:
```
transform =  transforms.Compose([transforms.ToTensor(),transforms.Normalize((0.5,0.
                                  ])
dir = '/content/gdrive/MyDrive/ColabNotebooks/Lab3_Gestures_Summer'
dataset = datasets.ImageFolder(root = dir, transform=transform)

train_size = int(0.6* len(dataset))
val_size = int(0.2* len(dataset))
test_size = len(dataset) - train_size - val_size

classes = ['A','B','C','D','E','F','G','H','I']

#data spilt
train_dataset , val_dataset, test_dataset = torch.utils.data.random_split(dataset,[

print("The Training dataset size:",train_size)
print("The Training dataset size:",val_size)
print("The Training dataset size:",test_size)
```

```
The Training dataset size: 1331
The Training dataset size: 443
The Training dataset size: 445
```

2. Model Building and Sanity Checking [15 pt]

Part (a) Convolutional Network - 5 pt

Build a convolutional neural network model that takes the (224x224 RGB) image as input, and predicts the gesture letter. Your model should be a subclass of nn.Module. Explain your choice of neural network architecture: how many layers did you choose? What types of layers did you use? Were they fully-connected or convolutional? What about other decisions like pooling layers, activation functions, number of channels / hidden units?

In [ ]:
```
class Gesture_CNN(nn.Module):
  def __init__(self):
      super(Gesture_CNN,self).__init__()
      self.name = "Gesture"
      self.conv1 = nn.Conv2d(3, 5, 5) #RGB 3 Channels inputt channel , 5x5 kernel s
```

```
        self.pool = nn.MaxPool2d(2, 2) #2x2 max pooling
        self.conv2 = nn.Conv2d(5, 10, 5) #conv layer 10filter 5x5
        self.fc1 = nn.Linear(10 * 53 * 53, 32) # got 53 from output size computation
        self.fc2 = nn.Linear(32, 9) # 9 output because 9 channnels

    def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = self.pool(F.relu(self.conv2(x)))
        x = x.view(-1, 10 * 53 * 53)
        x = F.relu(self.fc1(x))
        x = self.fc2(x)
        x = x.squeeze(1) # Flatten to [batch_size]
        return x
```

I choose 2 convolutional layers, max pooling layer (2,2), used relu activation function and 2 fully connected layer. Similar to lab2 approach. size of output dimension computed using output size computation formula.

Part (b) Training Code - 5 pt

Write code that trains your neural network given some training data. Your training code should make it easy to tweak the usual hyperparameters, like batch size, learning rate, and the model object itself. Make sure that you are checkpointing your models from time to time (the frequency is up to you). Explain your choice of loss function and optimizer.

In [50]:
```
def get_accuracy(model,data,batch_size ): #referred tut3


    correct = 0
    total = 0
    for imgs, labels in torch.utils.data.DataLoader(data, batch_size=batch_size):
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
           imgs = imgs.cuda()
           labels = labels.cuda()
        output = model(imgs)

        #select index with maximum prediction score
        pred = output.max(1, keepdim=True)[1]
        correct += pred.eq(labels.view_as(pred)).sum().item()
        total += imgs.shape[0]
    return correct / total
```

In [ ]:
```
def train(model, data, batch_size , num_epochs,lr): #referred tut3
    train_loader = torch.utils.data.DataLoader(data, batch_size=batch_size)
    # train_loader = torch.utils.data.DataLoader(train_data, batch_size=batch_size,
                                           #num_workers=num_workers, shuffle=True)

    criterion = nn.CrossEntropyLoss()
    optimizer = optim.SGD(model.parameters(), lr, momentum=0.9)

    iters, losses, train_acc, val_acc = [], [], [], []
```

```
# training
n = 0 # the number of iterations
start_time=time.time()
for epoch in range(num_epochs):
    mini_b=0
    mini_batch_correct = 0
    Mini_batch_total = 0
    for imgs, labels in iter(train_loader):


        ##############################################
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
          imgs = imgs.cuda()
          labels = labels.cuda()
        ##############################################


        out = model(imgs)             # forward pass
        loss = criterion(out, labels) # compute the total loss
        loss.backward()               # backward pass (compute parameter update
        optimizer.step()              # make the updates for each parameter
        optimizer.zero_grad()         # a clean up step for PyTorch
              # save the current training information



        ##### Mini_batch Accuracy ##### We don't compute accuracy on the whole
        pred = out.max(1, keepdim=True)[1]
        mini_batch_correct = pred.eq(labels.view_as(pred)).sum().item()
        Mini_batch_total = imgs.shape[0]
        # Append mini-batch accuracy for the training curve
        train_acc.append((mini_batch_correct / Mini_batch_total))
       ############################

      # save the current training information
        iters.append(n)
        losses.append(float(loss)/batch_size)             # compute *average* l
        val_acc.append(get_accuracy(model, val_dataset, batch_size))  # compute
        n += 1
        mini_b += 1
        print("Iteration: ",n,'Progress: % 6.2f ' % ((epoch * len(train_loader)


    print ("Epoch %d Finished. " % epoch ,"Time per Epoch: % 6.2f s "% ((time.t


end_time= time.time()
# plotting
plt.title("Training Curve")
plt.plot(iters, losses, label="Train")
plt.xlabel("Iterations")
plt.ylabel("Loss")
plt.show()
```

```
    plt.title("Training Curve")
    plt.plot(iters, train_acc, label="Training")
    plt.plot(iters, val_acc, label="Validation")
    plt.xlabel("Iterations")
    plt.ylabel("Validation Accuracy")
    plt.legend(loc='best')
    plt.show()

    train_acc.append(get_accuracy(model, data, batch_size))
    val_acc.append(get_accuracy(model, val_dataset, batch_size))
    print("Final Training Accuracy: {}".format(train_acc[-1]))
    print("Final Validation Accuracy: {}".format(val_acc[-1]))
    print ("Total time:  % 6.2f s  Time per Epoch: % 6.2f s " % ( (end_time-start_t
    torch.save(model.state_dict(), f'{model.name}_bs{batch_size}_lr{lr}_epoch{num_e
```

I choose Cross Entropy Loss function because it is used for multi-classfication problem as we look for 9 gestures. And the optimizer , SGD(Stochastic Gradient Descent) with momentum helps accelerate SGD in the relevant direction and dampens osscilation, increases for dimen whose gradients point in the same directions and reduces update for dimens whose gradients change direction.(referred lecture notes)

Part (c) “Overfit” to a Small Dataset - 5 pt

One way to sanity check our neural network model and training code is to check whether the model is capable of “overfitting” or “memorizing” a small dataset. A properly constructed CNN with correct training code should be able to memorize the answers to a small number of images quickly.

Construct a small dataset (e.g. just the images that you have collected). Then show that your model and training code is capable of memorizing the labels of this small data set.

With a large batch size (e.g. the entire small dataset) and learning rate that is not too high, You should be able to obtain a 100% training accuracy on that small dataset relatively quickly (within 200 iterations).

In [ ]:
```
def train_small(model, data, batch_size , num_epochs):
    train_loader = torch.utils.data.DataLoader(data, batch_size=batch_size)
    # train_loader = torch.utils.data.DataLoader(train_data, batch_size=batch_size,
                                          #num_workers=num_workers, shuffle=True)

    criterion = nn.CrossEntropyLoss()
    optimizer = optim.SGD(model.parameters(), lr=0.01, momentum=0.9)

    iters, losses, train_acc = [], [], []

    # training
    n = 0 # the number of iterations
    start_time=time.time()
    for epoch in range(num_epochs):
        mini_b=0
        mini_batch_correct = 0
```

```
    Mini_batch_total = 0
    for imgs, labels in iter(train_loader):


        ##############################################
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
          imgs = imgs.cuda()
          labels = labels.cuda()
        ##############################################


        out = model(imgs)             # forward pass
        loss = criterion(out, labels) # compute the total loss
        loss.backward()               # backward pass (compute parameter update
        optimizer.step()              # make the updates for each parameter
        optimizer.zero_grad()         # a clean up step for PyTorch
              # save the current training information



        ##### Mini_batch Accuracy ##### We don't compute accuracy on the whole
        pred = out.max(1, keepdim=True)[1]
        mini_batch_correct = pred.eq(labels.view_as(pred)).sum().item()
        Mini_batch_total = imgs.shape[0]
        # Append mini-batch accuracy for the training curve
        train_acc.append((mini_batch_correct / Mini_batch_total))
       ############################

      # save the current training information
        iters.append(n)
        losses.append(float(loss)/batch_size)             # compute *average* l
        n += 1
        mini_b += 1
        print("Iteration: ",n,'Progress: % 6.2f ' % ((epoch * len(train_loader)


    print ("Epoch %d Finished. " % epoch ,"Time per Epoch: % 6.2f s "% ((time.t


end_time= time.time()
# plotting
plt.title("Training Curve")
plt.plot(iters, losses, label="Train")
plt.xlabel("Iterations")
plt.ylabel("Loss")
plt.show()

plt.title("Training Curve")
plt.plot(iters, train_acc, label="Training")
plt.xlabel("Iterations")
plt.legend(loc='best')
plt.show()

train_acc.append(get_accuracy(model, data, batch_size))
print("Final Training Accuracy: {}".format(train_acc[-1]))
```

```
    print ("Total time:  % 6.2f s  Time per Epoch: % 6.2f s " % ( (end_time-start_t
```

In [ ]:

```
use_cuda = True
from torch.utils.data import Subset, DataLoader
small_dataset = Subset(dataset, list(range(20)))
small_loader = DataLoader(small_dataset, batch_size=20, shuffle=True)
model = Gesture_CNN()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')


train_small(model,small_dataset,batch_size=20, num_epochs=200)
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.50  % Time Elapsed:   0.33 s
Epoch 0 Finished.  Time per Epoch:   0.33 s
Iteration:  2 Progress:   1.00  % Time Elapsed:   0.64 s
Epoch 1 Finished.  Time per Epoch:   0.32 s
Iteration:  3 Progress:   1.50  % Time Elapsed:   0.97 s
Epoch 2 Finished.  Time per Epoch:   0.32 s
Iteration:  4 Progress:   2.00  % Time Elapsed:   1.30 s
Epoch 3 Finished.  Time per Epoch:   0.33 s
Iteration:  5 Progress:   2.50  % Time Elapsed:   1.62 s
Epoch 4 Finished.  Time per Epoch:   0.32 s
Iteration:  6 Progress:   3.00  % Time Elapsed:   1.94 s
Epoch 5 Finished.  Time per Epoch:   0.32 s
Iteration:  7 Progress:   3.50  % Time Elapsed:   2.27 s
Epoch 6 Finished.  Time per Epoch:   0.32 s
Iteration:  8 Progress:   4.00  % Time Elapsed:   2.58 s
Epoch 7 Finished.  Time per Epoch:   0.32 s
Iteration:  9 Progress:   4.50  % Time Elapsed:   3.32 s
Epoch 8 Finished.  Time per Epoch:   0.37 s
Iteration:  10 Progress:   5.00  % Time Elapsed:   4.40 s
Epoch 9 Finished.  Time per Epoch:   0.44 s
Iteration:  11 Progress:   5.50  % Time Elapsed:   5.43 s
Epoch 10 Finished.  Time per Epoch:   0.49 s
Iteration:  12 Progress:   6.00  % Time Elapsed:   5.87 s
Epoch 11 Finished.  Time per Epoch:   0.49 s
Iteration:  13 Progress:   6.50  % Time Elapsed:   6.34 s
Epoch 12 Finished.  Time per Epoch:   0.49 s
Iteration:  14 Progress:   7.00  % Time Elapsed:   6.76 s
Epoch 13 Finished.  Time per Epoch:   0.48 s
Iteration:  15 Progress:   7.50  % Time Elapsed:   7.19 s
Epoch 14 Finished.  Time per Epoch:   0.48 s
Iteration:  16 Progress:   8.00  % Time Elapsed:   7.62 s
Epoch 15 Finished.  Time per Epoch:   0.48 s
Iteration:  17 Progress:   8.50  % Time Elapsed:   8.05 s
Epoch 16 Finished.  Time per Epoch:   0.47 s
Iteration:  18 Progress:   9.00  % Time Elapsed:   8.50 s
Epoch 17 Finished.  Time per Epoch:   0.47 s
Iteration:  19 Progress:   9.50  % Time Elapsed:   8.85 s
Epoch 18 Finished.  Time per Epoch:   0.47 s
Iteration:  20 Progress:  10.00  % Time Elapsed:   9.20 s
Epoch 19 Finished.  Time per Epoch:   0.46 s
Iteration:  21 Progress:  10.50  % Time Elapsed:   9.53 s
Epoch 20 Finished.  Time per Epoch:   0.45 s
Iteration:  22 Progress:  11.00  % Time Elapsed:   9.84 s
Epoch 21 Finished.  Time per Epoch:   0.45 s
Iteration:  23 Progress:  11.50  % Time Elapsed:  10.18 s
Epoch 22 Finished.  Time per Epoch:   0.44 s
Iteration:  24 Progress:  12.00  % Time Elapsed:  10.49 s
Epoch 23 Finished.  Time per Epoch:   0.44 s
Iteration:  25 Progress:  12.50  % Time Elapsed:  10.80 s
Epoch 24 Finished.  Time per Epoch:   0.43 s
Iteration:  26 Progress:  13.00  % Time Elapsed:  11.13 s
Epoch 25 Finished.  Time per Epoch:   0.43 s
Iteration:  27 Progress:  13.50  % Time Elapsed:  11.45 s
Epoch 26 Finished.  Time per Epoch:   0.42 s
Iteration:  28 Progress:  14.00  % Time Elapsed:  11.75 s
```

```
Epoch 27 Finished.  Time per Epoch:   0.42 s
Iteration:  29 Progress:  14.50  % Time Elapsed:  12.06 s
Epoch 28 Finished.  Time per Epoch:   0.42 s
Iteration:  30 Progress:  15.00  % Time Elapsed:  12.41 s
Epoch 29 Finished.  Time per Epoch:   0.41 s
Iteration:  31 Progress:  15.50  % Time Elapsed:  12.72 s
Epoch 30 Finished.  Time per Epoch:   0.41 s
Iteration:  32 Progress:  16.00  % Time Elapsed:  13.02 s
Epoch 31 Finished.  Time per Epoch:   0.41 s
Iteration:  33 Progress:  16.50  % Time Elapsed:  13.37 s
Epoch 32 Finished.  Time per Epoch:   0.41 s
Iteration:  34 Progress:  17.00  % Time Elapsed:  13.68 s
Epoch 33 Finished.  Time per Epoch:   0.40 s
Iteration:  35 Progress:  17.50  % Time Elapsed:  13.98 s
Epoch 34 Finished.  Time per Epoch:   0.40 s
Iteration:  36 Progress:  18.00  % Time Elapsed:  14.32 s
Epoch 35 Finished.  Time per Epoch:   0.40 s
Iteration:  37 Progress:  18.50  % Time Elapsed:  14.64 s
Epoch 36 Finished.  Time per Epoch:   0.40 s
Iteration:  38 Progress:  19.00  % Time Elapsed:  14.95 s
Epoch 37 Finished.  Time per Epoch:   0.39 s
Iteration:  39 Progress:  19.50  % Time Elapsed:  15.27 s
Epoch 38 Finished.  Time per Epoch:   0.39 s
Iteration:  40 Progress:  20.00  % Time Elapsed:  15.60 s
Epoch 39 Finished.  Time per Epoch:   0.39 s
Iteration:  41 Progress:  20.50  % Time Elapsed:  15.91 s
Epoch 40 Finished.  Time per Epoch:   0.39 s
Iteration:  42 Progress:  21.00  % Time Elapsed:  16.22 s
Epoch 41 Finished.  Time per Epoch:   0.39 s
Iteration:  43 Progress:  21.50  % Time Elapsed:  16.55 s
Epoch 42 Finished.  Time per Epoch:   0.38 s
Iteration:  44 Progress:  22.00  % Time Elapsed:  16.86 s
Epoch 43 Finished.  Time per Epoch:   0.38 s
Iteration:  45 Progress:  22.50  % Time Elapsed:  17.18 s
Epoch 44 Finished.  Time per Epoch:   0.38 s
Iteration:  46 Progress:  23.00  % Time Elapsed:  17.52 s
Epoch 45 Finished.  Time per Epoch:   0.38 s
Iteration:  47 Progress:  23.50  % Time Elapsed:  17.84 s
Epoch 46 Finished.  Time per Epoch:   0.38 s
Iteration:  48 Progress:  24.00  % Time Elapsed:  18.16 s
Epoch 47 Finished.  Time per Epoch:   0.38 s
Iteration:  49 Progress:  24.50  % Time Elapsed:  18.49 s
Epoch 48 Finished.  Time per Epoch:   0.38 s
Iteration:  50 Progress:  25.00  % Time Elapsed:  18.90 s
Epoch 49 Finished.  Time per Epoch:   0.38 s
Iteration:  51 Progress:  25.50  % Time Elapsed:  19.34 s
Epoch 50 Finished.  Time per Epoch:   0.38 s
Iteration:  52 Progress:  26.00  % Time Elapsed:  19.77 s
Epoch 51 Finished.  Time per Epoch:   0.38 s
Iteration:  53 Progress:  26.50  % Time Elapsed:  20.19 s
Epoch 52 Finished.  Time per Epoch:   0.38 s
Iteration:  54 Progress:  27.00  % Time Elapsed:  20.63 s
Epoch 53 Finished.  Time per Epoch:   0.38 s
Iteration:  55 Progress:  27.50  % Time Elapsed:  21.06 s
Epoch 54 Finished.  Time per Epoch:   0.38 s
Iteration:  56 Progress:  28.00  % Time Elapsed:  21.50 s
```

```
Epoch 55 Finished.  Time per Epoch:   0.38 s
Iteration:  57 Progress:  28.50  % Time Elapsed:  21.94 s
Epoch 56 Finished.  Time per Epoch:   0.39 s
Iteration:  58 Progress:  29.00  % Time Elapsed:  22.38 s
Epoch 57 Finished.  Time per Epoch:   0.39 s
Iteration:  59 Progress:  29.50  % Time Elapsed:  22.71 s
Epoch 58 Finished.  Time per Epoch:   0.38 s
Iteration:  60 Progress:  30.00  % Time Elapsed:  23.02 s
Epoch 59 Finished.  Time per Epoch:   0.38 s
Iteration:  61 Progress:  30.50  % Time Elapsed:  23.33 s
Epoch 60 Finished.  Time per Epoch:   0.38 s
Iteration:  62 Progress:  31.00  % Time Elapsed:  23.66 s
Epoch 61 Finished.  Time per Epoch:   0.38 s
Iteration:  63 Progress:  31.50  % Time Elapsed:  23.98 s
Epoch 62 Finished.  Time per Epoch:   0.38 s
Iteration:  64 Progress:  32.00  % Time Elapsed:  24.29 s
Epoch 63 Finished.  Time per Epoch:   0.38 s
Iteration:  65 Progress:  32.50  % Time Elapsed:  24.61 s
Epoch 64 Finished.  Time per Epoch:   0.38 s
Iteration:  66 Progress:  33.00  % Time Elapsed:  24.94 s
Epoch 65 Finished.  Time per Epoch:   0.38 s
Iteration:  67 Progress:  33.50  % Time Elapsed:  25.25 s
Epoch 66 Finished.  Time per Epoch:   0.38 s
Iteration:  68 Progress:  34.00  % Time Elapsed:  25.58 s
Epoch 67 Finished.  Time per Epoch:   0.38 s
Iteration:  69 Progress:  34.50  % Time Elapsed:  25.92 s
Epoch 68 Finished.  Time per Epoch:   0.38 s
Iteration:  70 Progress:  35.00  % Time Elapsed:  26.23 s
Epoch 69 Finished.  Time per Epoch:   0.37 s
Iteration:  71 Progress:  35.50  % Time Elapsed:  26.55 s
Epoch 70 Finished.  Time per Epoch:   0.37 s
Iteration:  72 Progress:  36.00  % Time Elapsed:  26.87 s
Epoch 71 Finished.  Time per Epoch:   0.37 s
Iteration:  73 Progress:  36.50  % Time Elapsed:  27.20 s
Epoch 72 Finished.  Time per Epoch:   0.37 s
Iteration:  74 Progress:  37.00  % Time Elapsed:  27.51 s
Epoch 73 Finished.  Time per Epoch:   0.37 s
Iteration:  75 Progress:  37.50  % Time Elapsed:  27.84 s
Epoch 74 Finished.  Time per Epoch:   0.37 s
Iteration:  76 Progress:  38.00  % Time Elapsed:  28.17 s
Epoch 75 Finished.  Time per Epoch:   0.37 s
Iteration:  77 Progress:  38.50  % Time Elapsed:  28.50 s
Epoch 76 Finished.  Time per Epoch:   0.37 s
Iteration:  78 Progress:  39.00  % Time Elapsed:  28.83 s
Epoch 77 Finished.  Time per Epoch:   0.37 s
Iteration:  79 Progress:  39.50  % Time Elapsed:  29.16 s
Epoch 78 Finished.  Time per Epoch:   0.37 s
Iteration:  80 Progress:  40.00  % Time Elapsed:  29.49 s
Epoch 79 Finished.  Time per Epoch:   0.37 s
Iteration:  81 Progress:  40.50  % Time Elapsed:  29.84 s
Epoch 80 Finished.  Time per Epoch:   0.37 s
Iteration:  82 Progress:  41.00  % Time Elapsed:  30.17 s
Epoch 81 Finished.  Time per Epoch:   0.37 s
Iteration:  83 Progress:  41.50  % Time Elapsed:  30.48 s
Epoch 82 Finished.  Time per Epoch:   0.37 s
Iteration:  84 Progress:  42.00  % Time Elapsed:  30.80 s
```

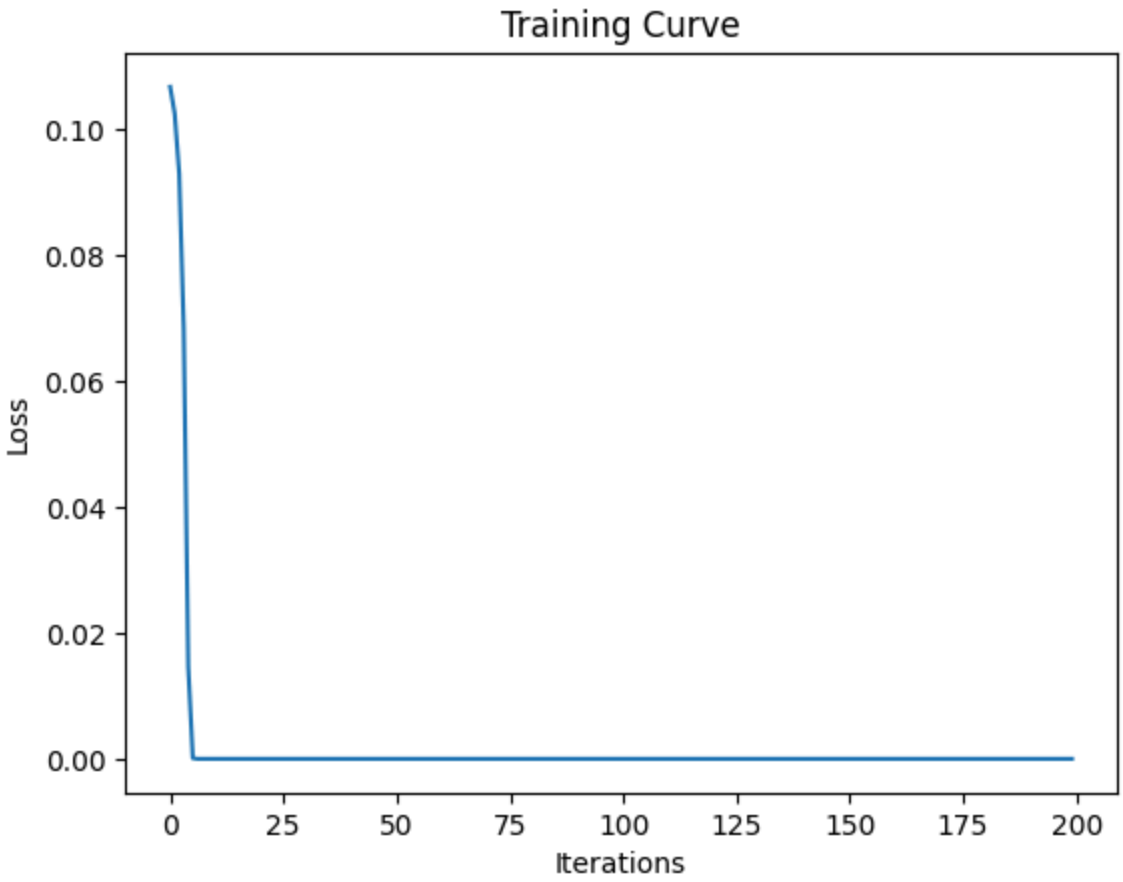
```
Epoch 83 Finished.  Time per Epoch:   0.37 s
Iteration:  85 Progress:  42.50  % Time Elapsed:  31.14 s
Epoch 84 Finished.  Time per Epoch:   0.37 s
Iteration:  86 Progress:  43.00  % Time Elapsed:  31.47 s
Epoch 85 Finished.  Time per Epoch:   0.37 s
Iteration:  87 Progress:  43.50  % Time Elapsed:  31.79 s
Epoch 86 Finished.  Time per Epoch:   0.37 s
Iteration:  88 Progress:  44.00  % Time Elapsed:  32.12 s
Epoch 87 Finished.  Time per Epoch:   0.37 s
Iteration:  89 Progress:  44.50  % Time Elapsed:  32.46 s
Epoch 88 Finished.  Time per Epoch:   0.36 s
Iteration:  90 Progress:  45.00  % Time Elapsed:  32.88 s
Epoch 89 Finished.  Time per Epoch:   0.37 s
Iteration:  91 Progress:  45.50  % Time Elapsed:  33.33 s
Epoch 90 Finished.  Time per Epoch:   0.37 s
Iteration:  92 Progress:  46.00  % Time Elapsed:  33.76 s
Epoch 91 Finished.  Time per Epoch:   0.37 s
Iteration:  93 Progress:  46.50  % Time Elapsed:  34.19 s
Epoch 92 Finished.  Time per Epoch:   0.37 s
Iteration:  94 Progress:  47.00  % Time Elapsed:  34.66 s
Epoch 93 Finished.  Time per Epoch:   0.37 s
Iteration:  95 Progress:  47.50  % Time Elapsed:  35.08 s
Epoch 94 Finished.  Time per Epoch:   0.37 s
Iteration:  96 Progress:  48.00  % Time Elapsed:  35.52 s
Epoch 95 Finished.  Time per Epoch:   0.37 s
Iteration:  97 Progress:  48.50  % Time Elapsed:  35.95 s
Epoch 96 Finished.  Time per Epoch:   0.37 s
Iteration:  98 Progress:  49.00  % Time Elapsed:  36.35 s
Epoch 97 Finished.  Time per Epoch:   0.37 s
Iteration:  99 Progress:  49.50  % Time Elapsed:  36.66 s
Epoch 98 Finished.  Time per Epoch:   0.37 s
Iteration:  100 Progress:  50.00  % Time Elapsed:  36.98 s
Epoch 99 Finished.  Time per Epoch:   0.37 s
Iteration:  101 Progress:  50.50  % Time Elapsed:  37.31 s
Epoch 100 Finished.  Time per Epoch:   0.37 s
Iteration:  102 Progress:  51.00  % Time Elapsed:  37.63 s
Epoch 101 Finished.  Time per Epoch:   0.37 s
Iteration:  103 Progress:  51.50  % Time Elapsed:  37.94 s
Epoch 102 Finished.  Time per Epoch:   0.37 s
Iteration:  104 Progress:  52.00  % Time Elapsed:  38.28 s
Epoch 103 Finished.  Time per Epoch:   0.37 s
Iteration:  105 Progress:  52.50  % Time Elapsed:  38.61 s
Epoch 104 Finished.  Time per Epoch:   0.37 s
Iteration:  106 Progress:  53.00  % Time Elapsed:  38.92 s
Epoch 105 Finished.  Time per Epoch:   0.37 s
Iteration:  107 Progress:  53.50  % Time Elapsed:  39.25 s
Epoch 106 Finished.  Time per Epoch:   0.37 s
Iteration:  108 Progress:  54.00  % Time Elapsed:  39.58 s
Epoch 107 Finished.  Time per Epoch:   0.37 s
Iteration:  109 Progress:  54.50  % Time Elapsed:  40.20 s
Epoch 108 Finished.  Time per Epoch:   0.37 s
Iteration:  110 Progress:  55.00  % Time Elapsed:  40.52 s
Epoch 109 Finished.  Time per Epoch:   0.37 s
Iteration:  111 Progress:  55.50  % Time Elapsed:  40.85 s
Epoch 110 Finished.  Time per Epoch:   0.37 s
Iteration:  112 Progress:  56.00  % Time Elapsed:  41.17 s
```

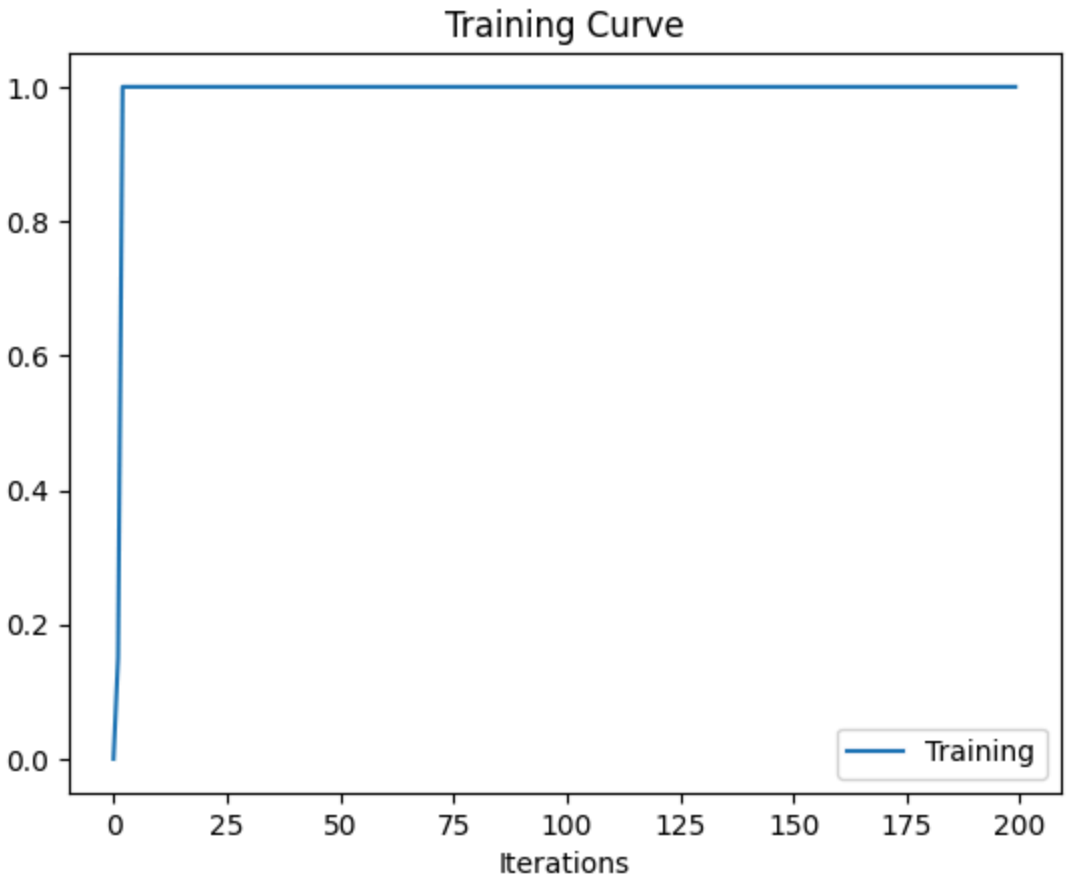
```
Epoch 111 Finished.  Time per Epoch:   0.37 s
Iteration:  113 Progress:  56.50  % Time Elapsed:  41.49 s
Epoch 112 Finished.  Time per Epoch:   0.37 s
Iteration:  114 Progress:  57.00  % Time Elapsed:  41.83 s
Epoch 113 Finished.  Time per Epoch:   0.37 s
Iteration:  115 Progress:  57.50  % Time Elapsed:  42.14 s
Epoch 114 Finished.  Time per Epoch:   0.37 s
Iteration:  116 Progress:  58.00  % Time Elapsed:  42.45 s
Epoch 115 Finished.  Time per Epoch:   0.37 s
Iteration:  117 Progress:  58.50  % Time Elapsed:  42.79 s
Epoch 116 Finished.  Time per Epoch:   0.37 s
Iteration:  118 Progress:  59.00  % Time Elapsed:  43.11 s
Epoch 117 Finished.  Time per Epoch:   0.37 s
Iteration:  119 Progress:  59.50  % Time Elapsed:  43.42 s
Epoch 118 Finished.  Time per Epoch:   0.36 s
Iteration:  120 Progress:  60.00  % Time Elapsed:  43.78 s
Epoch 119 Finished.  Time per Epoch:   0.36 s
Iteration:  121 Progress:  60.50  % Time Elapsed:  44.09 s
Epoch 120 Finished.  Time per Epoch:   0.36 s
Iteration:  122 Progress:  61.00  % Time Elapsed:  44.41 s
Epoch 121 Finished.  Time per Epoch:   0.36 s
Iteration:  123 Progress:  61.50  % Time Elapsed:  44.75 s
Epoch 122 Finished.  Time per Epoch:   0.36 s
Iteration:  124 Progress:  62.00  % Time Elapsed:  45.07 s
Epoch 123 Finished.  Time per Epoch:   0.36 s
Iteration:  125 Progress:  62.50  % Time Elapsed:  45.39 s
Epoch 124 Finished.  Time per Epoch:   0.36 s
Iteration:  126 Progress:  63.00  % Time Elapsed:  45.71 s
Epoch 125 Finished.  Time per Epoch:   0.36 s
Iteration:  127 Progress:  63.50  % Time Elapsed:  46.04 s
Epoch 126 Finished.  Time per Epoch:   0.36 s
Iteration:  128 Progress:  64.00  % Time Elapsed:  46.41 s
Epoch 127 Finished.  Time per Epoch:   0.36 s
Iteration:  129 Progress:  64.50  % Time Elapsed:  46.85 s
Epoch 128 Finished.  Time per Epoch:   0.36 s
Iteration:  130 Progress:  65.00  % Time Elapsed:  47.29 s
Epoch 129 Finished.  Time per Epoch:   0.36 s
Iteration:  131 Progress:  65.50  % Time Elapsed:  47.71 s
Epoch 130 Finished.  Time per Epoch:   0.36 s
Iteration:  132 Progress:  66.00  % Time Elapsed:  48.15 s
Epoch 131 Finished.  Time per Epoch:   0.36 s
Iteration:  133 Progress:  66.50  % Time Elapsed:  48.61 s
Epoch 132 Finished.  Time per Epoch:   0.37 s
Iteration:  134 Progress:  67.00  % Time Elapsed:  49.03 s
Epoch 133 Finished.  Time per Epoch:   0.37 s
Iteration:  135 Progress:  67.50  % Time Elapsed:  49.46 s
Epoch 134 Finished.  Time per Epoch:   0.37 s
Iteration:  136 Progress:  68.00  % Time Elapsed:  49.92 s
Epoch 135 Finished.  Time per Epoch:   0.37 s
Iteration:  137 Progress:  68.50  % Time Elapsed:  50.24 s
Epoch 136 Finished.  Time per Epoch:   0.37 s
Iteration:  138 Progress:  69.00  % Time Elapsed:  50.56 s
Epoch 137 Finished.  Time per Epoch:   0.37 s
Iteration:  139 Progress:  69.50  % Time Elapsed:  50.88 s
Epoch 138 Finished.  Time per Epoch:   0.37 s
Iteration:  140 Progress:  70.00  % Time Elapsed:  51.23 s
```

```
Epoch 139 Finished.  Time per Epoch:   0.37 s
Iteration:  141 Progress:  70.50  % Time Elapsed:  51.55 s
Epoch 140 Finished.  Time per Epoch:   0.37 s
Iteration:  142 Progress:  71.00  % Time Elapsed:  51.87 s
Epoch 141 Finished.  Time per Epoch:   0.37 s
Iteration:  143 Progress:  71.50  % Time Elapsed:  52.21 s
Epoch 142 Finished.  Time per Epoch:   0.37 s
Iteration:  144 Progress:  72.00  % Time Elapsed:  52.53 s
Epoch 143 Finished.  Time per Epoch:   0.36 s
Iteration:  145 Progress:  72.50  % Time Elapsed:  52.84 s
Epoch 144 Finished.  Time per Epoch:   0.36 s
Iteration:  146 Progress:  73.00  % Time Elapsed:  53.19 s
Epoch 145 Finished.  Time per Epoch:   0.36 s
Iteration:  147 Progress:  73.50  % Time Elapsed:  53.50 s
Epoch 146 Finished.  Time per Epoch:   0.36 s
Iteration:  148 Progress:  74.00  % Time Elapsed:  53.82 s
Epoch 147 Finished.  Time per Epoch:   0.36 s
Iteration:  149 Progress:  74.50  % Time Elapsed:  54.16 s
Epoch 148 Finished.  Time per Epoch:   0.36 s
Iteration:  150 Progress:  75.00  % Time Elapsed:  54.47 s
Epoch 149 Finished.  Time per Epoch:   0.36 s
Iteration:  151 Progress:  75.50  % Time Elapsed:  54.79 s
Epoch 150 Finished.  Time per Epoch:   0.36 s
Iteration:  152 Progress:  76.00  % Time Elapsed:  55.12 s
Epoch 151 Finished.  Time per Epoch:   0.36 s
Iteration:  153 Progress:  76.50  % Time Elapsed:  55.44 s
Epoch 152 Finished.  Time per Epoch:   0.36 s
Iteration:  154 Progress:  77.00  % Time Elapsed:  55.75 s
Epoch 153 Finished.  Time per Epoch:   0.36 s
Iteration:  155 Progress:  77.50  % Time Elapsed:  56.06 s
Epoch 154 Finished.  Time per Epoch:   0.36 s
Iteration:  156 Progress:  78.00  % Time Elapsed:  56.41 s
Epoch 155 Finished.  Time per Epoch:   0.36 s
Iteration:  157 Progress:  78.50  % Time Elapsed:  56.72 s
Epoch 156 Finished.  Time per Epoch:   0.36 s
Iteration:  158 Progress:  79.00  % Time Elapsed:  57.03 s
Epoch 157 Finished.  Time per Epoch:   0.36 s
Iteration:  159 Progress:  79.50  % Time Elapsed:  57.38 s
Epoch 158 Finished.  Time per Epoch:   0.36 s
Iteration:  160 Progress:  80.00  % Time Elapsed:  57.69 s
Epoch 159 Finished.  Time per Epoch:   0.36 s
Iteration:  161 Progress:  80.50  % Time Elapsed:  58.01 s
Epoch 160 Finished.  Time per Epoch:   0.36 s
Iteration:  162 Progress:  81.00  % Time Elapsed:  58.35 s
Epoch 161 Finished.  Time per Epoch:   0.36 s
Iteration:  163 Progress:  81.50  % Time Elapsed:  58.67 s
Epoch 162 Finished.  Time per Epoch:   0.36 s
Iteration:  164 Progress:  82.00  % Time Elapsed:  58.98 s
Epoch 163 Finished.  Time per Epoch:   0.36 s
Iteration:  165 Progress:  82.50  % Time Elapsed:  59.31 s
Epoch 164 Finished.  Time per Epoch:   0.36 s
Iteration:  166 Progress:  83.00  % Time Elapsed:  59.63 s
Epoch 165 Finished.  Time per Epoch:   0.36 s
Iteration:  167 Progress:  83.50  % Time Elapsed:  59.96 s
Epoch 166 Finished.  Time per Epoch:   0.36 s
Iteration:  168 Progress:  84.00  % Time Elapsed:  60.38 s
```

```
Epoch 167 Finished.  Time per Epoch:   0.36 s
Iteration:  169 Progress:  84.50  % Time Elapsed:  60.83 s
Epoch 168 Finished.  Time per Epoch:   0.36 s
Iteration:  170 Progress:  85.00  % Time Elapsed:  61.24 s
Epoch 169 Finished.  Time per Epoch:   0.36 s
Iteration:  171 Progress:  85.50  % Time Elapsed:  61.68 s
Epoch 170 Finished.  Time per Epoch:   0.36 s
Iteration:  172 Progress:  86.00  % Time Elapsed:  62.12 s
Epoch 171 Finished.  Time per Epoch:   0.36 s
Iteration:  173 Progress:  86.50  % Time Elapsed:  62.55 s
Epoch 172 Finished.  Time per Epoch:   0.36 s
Iteration:  174 Progress:  87.00  % Time Elapsed:  62.98 s
Epoch 173 Finished.  Time per Epoch:   0.36 s
Iteration:  175 Progress:  87.50  % Time Elapsed:  63.43 s
Epoch 174 Finished.  Time per Epoch:   0.36 s
Iteration:  176 Progress:  88.00  % Time Elapsed:  63.85 s
Epoch 175 Finished.  Time per Epoch:   0.36 s
Iteration:  177 Progress:  88.50  % Time Elapsed:  64.17 s
Epoch 176 Finished.  Time per Epoch:   0.36 s
Iteration:  178 Progress:  89.00  % Time Elapsed:  64.51 s
Epoch 177 Finished.  Time per Epoch:   0.36 s
Iteration:  179 Progress:  89.50  % Time Elapsed:  64.84 s
Epoch 178 Finished.  Time per Epoch:   0.36 s
Iteration:  180 Progress:  90.00  % Time Elapsed:  65.15 s
Epoch 179 Finished.  Time per Epoch:   0.36 s
Iteration:  181 Progress:  90.50  % Time Elapsed:  65.48 s
Epoch 180 Finished.  Time per Epoch:   0.36 s
Iteration:  182 Progress:  91.00  % Time Elapsed:  65.80 s
Epoch 181 Finished.  Time per Epoch:   0.36 s
Iteration:  183 Progress:  91.50  % Time Elapsed:  66.11 s
Epoch 182 Finished.  Time per Epoch:   0.36 s
Iteration:  184 Progress:  92.00  % Time Elapsed:  66.43 s
Epoch 183 Finished.  Time per Epoch:   0.36 s
Iteration:  185 Progress:  92.50  % Time Elapsed:  66.77 s
Epoch 184 Finished.  Time per Epoch:   0.36 s
Iteration:  186 Progress:  93.00  % Time Elapsed:  67.08 s
Epoch 185 Finished.  Time per Epoch:   0.36 s
Iteration:  187 Progress:  93.50  % Time Elapsed:  67.39 s
Epoch 186 Finished.  Time per Epoch:   0.36 s
Iteration:  188 Progress:  94.00  % Time Elapsed:  67.72 s
Epoch 187 Finished.  Time per Epoch:   0.36 s
Iteration:  189 Progress:  94.50  % Time Elapsed:  68.04 s
Epoch 188 Finished.  Time per Epoch:   0.36 s
Iteration:  190 Progress:  95.00  % Time Elapsed:  68.35 s
Epoch 189 Finished.  Time per Epoch:   0.36 s
Iteration:  191 Progress:  95.50  % Time Elapsed:  68.68 s
Epoch 190 Finished.  Time per Epoch:   0.36 s
Iteration:  192 Progress:  96.00  % Time Elapsed:  69.00 s
Epoch 191 Finished.  Time per Epoch:   0.36 s
Iteration:  193 Progress:  96.50  % Time Elapsed:  69.32 s
Epoch 192 Finished.  Time per Epoch:   0.36 s
Iteration:  194 Progress:  97.00  % Time Elapsed:  69.64 s
Epoch 193 Finished.  Time per Epoch:   0.36 s
Iteration:  195 Progress:  97.50  % Time Elapsed:  69.97 s
Epoch 194 Finished.  Time per Epoch:   0.36 s
Iteration:  196 Progress:  98.00  % Time Elapsed:  70.28 s
```

```
Epoch 195 Finished.  Time per Epoch:   0.36 s
Iteration:  197 Progress:  98.50  % Time Elapsed:  70.59 s
Epoch 196 Finished.  Time per Epoch:   0.36 s
Iteration:  198 Progress:  99.00  % Time Elapsed:  70.94 s
Epoch 197 Finished.  Time per Epoch:   0.36 s
Iteration:  199 Progress:  99.50  % Time Elapsed:  71.25 s
Epoch 198 Finished.  Time per Epoch:   0.36 s
Iteration:  200 Progress:  100.00  % Time Elapsed:  71.57 s
Epoch 199 Finished.  Time per Epoch:   0.36 s
```






```
Final Training Accuracy: 1.0
Total time:   71.57 s  Time per Epoch:   0.36 s
```

3. Hyperparameter Search [15 pt]

Part (a) - 3 pt

List 3 hyperparameters that you think are most worth tuning. Choose at least one hyperparameter related to the model architecture.

In [ ]:
```
#Batch Size, Learning Rate, Number of Layers CNN
```

Part (b) - 5 pt

Tune the hyperparameters you listed in Part (a), trying as many values as you need to until you feel satisfied that you are getting a good model. Plot the training curve of at least 4 different hyperparameter settings.

In [ ]:
```
use_cuda = True
model = Gesture_CNN()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
```

```
  print('CUDA is not available.  Training on CPU ...')

train(model,train_dataset,batch_size=64, num_epochs=20, lr=0.02)
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.24  % Time Elapsed:   7.15 s
Iteration:  2 Progress:   0.48  % Time Elapsed:  14.57 s
Iteration:  3 Progress:   0.71  % Time Elapsed:  21.84 s
Iteration:  4 Progress:   0.95  % Time Elapsed:  29.00 s
Iteration:  5 Progress:   1.19  % Time Elapsed:  36.48 s
Iteration:  6 Progress:   1.43  % Time Elapsed:  43.34 s
Iteration:  7 Progress:   1.67  % Time Elapsed:  51.07 s
Iteration:  8 Progress:   1.90  % Time Elapsed:  57.93 s
Iteration:  9 Progress:   2.14  % Time Elapsed:  65.62 s
Iteration:  10 Progress:   2.38  % Time Elapsed:  72.40 s
Iteration:  11 Progress:   2.62  % Time Elapsed:  80.09 s
Iteration:  12 Progress:   2.86  % Time Elapsed:  86.82 s
Iteration:  13 Progress:   3.10  % Time Elapsed:  94.39 s
Iteration:  14 Progress:   3.33  % Time Elapsed:  101.08 s
Iteration:  15 Progress:   3.57  % Time Elapsed:  108.72 s
Iteration:  16 Progress:   3.81  % Time Elapsed:  115.44 s
Iteration:  17 Progress:   4.05  % Time Elapsed:  123.17 s
Iteration:  18 Progress:   4.29  % Time Elapsed:  129.84 s
Iteration:  19 Progress:   4.52  % Time Elapsed:  137.52 s
Iteration:  20 Progress:   4.76  % Time Elapsed:  144.44 s
Iteration:  21 Progress:   5.00  % Time Elapsed:  151.56 s
Epoch 0 Finished.  Time per Epoch:  151.56 s
Iteration:  22 Progress:   5.24  % Time Elapsed:  158.62 s
Iteration:  23 Progress:   5.48  % Time Elapsed:  166.12 s
Iteration:  24 Progress:   5.71  % Time Elapsed:  173.48 s
Iteration:  25 Progress:   5.95  % Time Elapsed:  180.69 s
Iteration:  26 Progress:   6.19  % Time Elapsed:  188.28 s
Iteration:  27 Progress:   6.43  % Time Elapsed:  195.09 s
Iteration:  28 Progress:   6.67  % Time Elapsed:  202.65 s
Iteration:  29 Progress:   6.90  % Time Elapsed:  209.44 s
Iteration:  30 Progress:   7.14  % Time Elapsed:  217.06 s
Iteration:  31 Progress:   7.38  % Time Elapsed:  223.82 s
Iteration:  32 Progress:   7.62  % Time Elapsed:  231.57 s
Iteration:  33 Progress:   7.86  % Time Elapsed:  238.32 s
Iteration:  34 Progress:   8.10  % Time Elapsed:  245.93 s
Iteration:  35 Progress:   8.33  % Time Elapsed:  252.53 s
Iteration:  36 Progress:   8.57  % Time Elapsed:  260.17 s
Iteration:  37 Progress:   8.81  % Time Elapsed:  266.84 s
Iteration:  38 Progress:   9.05  % Time Elapsed:  274.53 s
Iteration:  39 Progress:   9.29  % Time Elapsed:  281.26 s
Iteration:  40 Progress:   9.52  % Time Elapsed:  289.39 s
Iteration:  41 Progress:   9.76  % Time Elapsed:  296.44 s
Iteration:  42 Progress:  10.00  % Time Elapsed:  303.47 s
Epoch 1 Finished.  Time per Epoch:  151.73 s
Iteration:  43 Progress:  10.24  % Time Elapsed:  310.43 s
Iteration:  44 Progress:  10.48  % Time Elapsed:  317.72 s
Iteration:  45 Progress:  10.71  % Time Elapsed:  324.98 s
Iteration:  46 Progress:  10.95  % Time Elapsed:  332.07 s
Iteration:  47 Progress:  11.19  % Time Elapsed:  339.46 s
Iteration:  48 Progress:  11.43  % Time Elapsed:  346.15 s
Iteration:  49 Progress:  11.67  % Time Elapsed:  353.77 s
Iteration:  50 Progress:  11.90  % Time Elapsed:  360.54 s
Iteration:  51 Progress:  12.14  % Time Elapsed:  368.04 s
Iteration:  52 Progress:  12.38  % Time Elapsed:  374.74 s
Iteration:  53 Progress:  12.62  % Time Elapsed:  382.31 s
```

```
Iteration:  54 Progress:  12.86  % Time Elapsed:  389.05 s
Iteration:  55 Progress:  13.10  % Time Elapsed:  396.74 s
Iteration:  56 Progress:  13.33  % Time Elapsed:  403.33 s
Iteration:  57 Progress:  13.57  % Time Elapsed:  410.78 s
Iteration:  58 Progress:  13.81  % Time Elapsed:  417.45 s
Iteration:  59 Progress:  14.05  % Time Elapsed:  425.11 s
Iteration:  60 Progress:  14.29  % Time Elapsed:  431.91 s
Iteration:  61 Progress:  14.52  % Time Elapsed:  439.62 s
Iteration:  62 Progress:  14.76  % Time Elapsed:  446.45 s
Iteration:  63 Progress:  15.00  % Time Elapsed:  453.48 s
Epoch 2 Finished.  Time per Epoch:  151.16 s
Iteration:  64 Progress:  15.24  % Time Elapsed:  460.13 s
Iteration:  65 Progress:  15.48  % Time Elapsed:  467.78 s
Iteration:  66 Progress:  15.71  % Time Elapsed:  474.80 s
Iteration:  67 Progress:  15.95  % Time Elapsed:  482.26 s
Iteration:  68 Progress:  16.19  % Time Elapsed:  489.53 s
Iteration:  69 Progress:  16.43  % Time Elapsed:  496.76 s
Iteration:  70 Progress:  16.67  % Time Elapsed:  504.33 s
Iteration:  71 Progress:  16.90  % Time Elapsed:  511.23 s
Iteration:  72 Progress:  17.14  % Time Elapsed:  518.71 s
Iteration:  73 Progress:  17.38  % Time Elapsed:  525.37 s
Iteration:  74 Progress:  17.62  % Time Elapsed:  532.88 s
Iteration:  75 Progress:  17.86  % Time Elapsed:  539.71 s
Iteration:  76 Progress:  18.10  % Time Elapsed:  547.32 s
Iteration:  77 Progress:  18.33  % Time Elapsed:  554.03 s
Iteration:  78 Progress:  18.57  % Time Elapsed:  561.58 s
Iteration:  79 Progress:  18.81  % Time Elapsed:  568.34 s
Iteration:  80 Progress:  19.05  % Time Elapsed:  575.90 s
Iteration:  81 Progress:  19.29  % Time Elapsed:  582.65 s
Iteration:  82 Progress:  19.52  % Time Elapsed:  590.44 s
Iteration:  83 Progress:  19.76  % Time Elapsed:  597.09 s
Iteration:  84 Progress:  20.00  % Time Elapsed:  604.33 s
Epoch 3 Finished.  Time per Epoch:  151.08 s
Iteration:  85 Progress:  20.24  % Time Elapsed:  611.22 s
Iteration:  86 Progress:  20.48  % Time Elapsed:  618.95 s
Iteration:  87 Progress:  20.71  % Time Elapsed:  625.82 s
Iteration:  88 Progress:  20.95  % Time Elapsed:  633.02 s
Iteration:  89 Progress:  21.19  % Time Elapsed:  640.04 s
Iteration:  90 Progress:  21.43  % Time Elapsed:  647.09 s
Iteration:  91 Progress:  21.67  % Time Elapsed:  654.09 s
Iteration:  92 Progress:  21.90  % Time Elapsed:  661.05 s
Iteration:  93 Progress:  22.14  % Time Elapsed:  668.25 s
Iteration:  94 Progress:  22.38  % Time Elapsed:  675.13 s
Iteration:  95 Progress:  22.62  % Time Elapsed:  682.39 s
Iteration:  96 Progress:  22.86  % Time Elapsed:  689.08 s
Iteration:  97 Progress:  23.10  % Time Elapsed:  696.11 s
Iteration:  98 Progress:  23.33  % Time Elapsed:  702.93 s
Iteration:  99 Progress:  23.57  % Time Elapsed:  710.14 s
Iteration:  100 Progress:  23.81  % Time Elapsed:  716.81 s
Iteration:  101 Progress:  24.05  % Time Elapsed:  724.16 s
Iteration:  102 Progress:  24.29  % Time Elapsed:  730.60 s
Iteration:  103 Progress:  24.52  % Time Elapsed:  737.89 s
Iteration:  104 Progress:  24.76  % Time Elapsed:  744.48 s
Iteration:  105 Progress:  25.00  % Time Elapsed:  751.05 s
Epoch 4 Finished.  Time per Epoch:  150.21 s
Iteration:  106 Progress:  25.24  % Time Elapsed:  757.68 s
```

```
Iteration:  107 Progress:  25.48  % Time Elapsed:  765.13 s
Iteration:  108 Progress:  25.71  % Time Elapsed:  771.88 s
Iteration:  109 Progress:  25.95  % Time Elapsed:  779.13 s
Iteration:  110 Progress:  26.19  % Time Elapsed:  785.85 s
Iteration:  111 Progress:  26.43  % Time Elapsed:  793.26 s
Iteration:  112 Progress:  26.67  % Time Elapsed:  799.69 s
Iteration:  113 Progress:  26.90  % Time Elapsed:  807.14 s
Iteration:  114 Progress:  27.14  % Time Elapsed:  813.66 s
Iteration:  115 Progress:  27.38  % Time Elapsed:  820.89 s
Iteration:  116 Progress:  27.62  % Time Elapsed:  827.42 s
Iteration:  117 Progress:  27.86  % Time Elapsed:  834.91 s
Iteration:  118 Progress:  28.10  % Time Elapsed:  841.58 s
Iteration:  119 Progress:  28.33  % Time Elapsed:  848.97 s
Iteration:  120 Progress:  28.57  % Time Elapsed:  855.62 s
Iteration:  121 Progress:  28.81  % Time Elapsed:  863.01 s
Iteration:  122 Progress:  29.05  % Time Elapsed:  869.55 s
Iteration:  123 Progress:  29.29  % Time Elapsed:  876.86 s
Iteration:  124 Progress:  29.52  % Time Elapsed:  883.49 s
Iteration:  125 Progress:  29.76  % Time Elapsed:  890.82 s
Iteration:  126 Progress:  30.00  % Time Elapsed:  897.00 s
Epoch 5 Finished.  Time per Epoch:  149.50 s
Iteration:  127 Progress:  30.24  % Time Elapsed:  904.38 s
Iteration:  128 Progress:  30.48  % Time Elapsed:  910.98 s
Iteration:  129 Progress:  30.71  % Time Elapsed:  922.05 s
Iteration:  130 Progress:  30.95  % Time Elapsed:  930.72 s
Iteration:  131 Progress:  31.19  % Time Elapsed:  937.32 s
Iteration:  132 Progress:  31.43  % Time Elapsed:  944.74 s
Iteration:  133 Progress:  31.67  % Time Elapsed:  951.27 s
Iteration:  134 Progress:  31.90  % Time Elapsed:  958.65 s
Iteration:  135 Progress:  32.14  % Time Elapsed:  965.23 s
Iteration:  136 Progress:  32.38  % Time Elapsed:  972.64 s
Iteration:  137 Progress:  32.62  % Time Elapsed:  979.04 s
Iteration:  138 Progress:  32.86  % Time Elapsed:  986.92 s
Iteration:  139 Progress:  33.10  % Time Elapsed:  993.38 s
Iteration:  140 Progress:  33.33  % Time Elapsed:  1000.63 s
Iteration:  141 Progress:  33.57  % Time Elapsed:  1007.33 s
Iteration:  142 Progress:  33.81  % Time Elapsed:  1014.78 s
Iteration:  143 Progress:  34.05  % Time Elapsed:  1021.38 s
Iteration:  144 Progress:  34.29  % Time Elapsed:  1028.86 s
Iteration:  145 Progress:  34.52  % Time Elapsed:  1035.46 s
Iteration:  146 Progress:  34.76  % Time Elapsed:  1042.80 s
Iteration:  147 Progress:  35.00  % Time Elapsed:  1048.93 s
Epoch 6 Finished.  Time per Epoch:  149.85 s
Iteration:  148 Progress:  35.24  % Time Elapsed:  1056.23 s
Iteration:  149 Progress:  35.48  % Time Elapsed:  1062.76 s
Iteration:  150 Progress:  35.71  % Time Elapsed:  1070.07 s
Iteration:  151 Progress:  35.95  % Time Elapsed:  1076.57 s
Iteration:  152 Progress:  36.19  % Time Elapsed:  1084.21 s
Iteration:  153 Progress:  36.43  % Time Elapsed:  1090.74 s
Iteration:  154 Progress:  36.67  % Time Elapsed:  1098.20 s
Iteration:  155 Progress:  36.90  % Time Elapsed:  1104.74 s
Iteration:  156 Progress:  37.14  % Time Elapsed:  1112.18 s
Iteration:  157 Progress:  37.38  % Time Elapsed:  1118.54 s
Iteration:  158 Progress:  37.62  % Time Elapsed:  1126.01 s
Iteration:  159 Progress:  37.86  % Time Elapsed:  1132.40 s
Iteration:  160 Progress:  38.10  % Time Elapsed:  1139.72 s
```

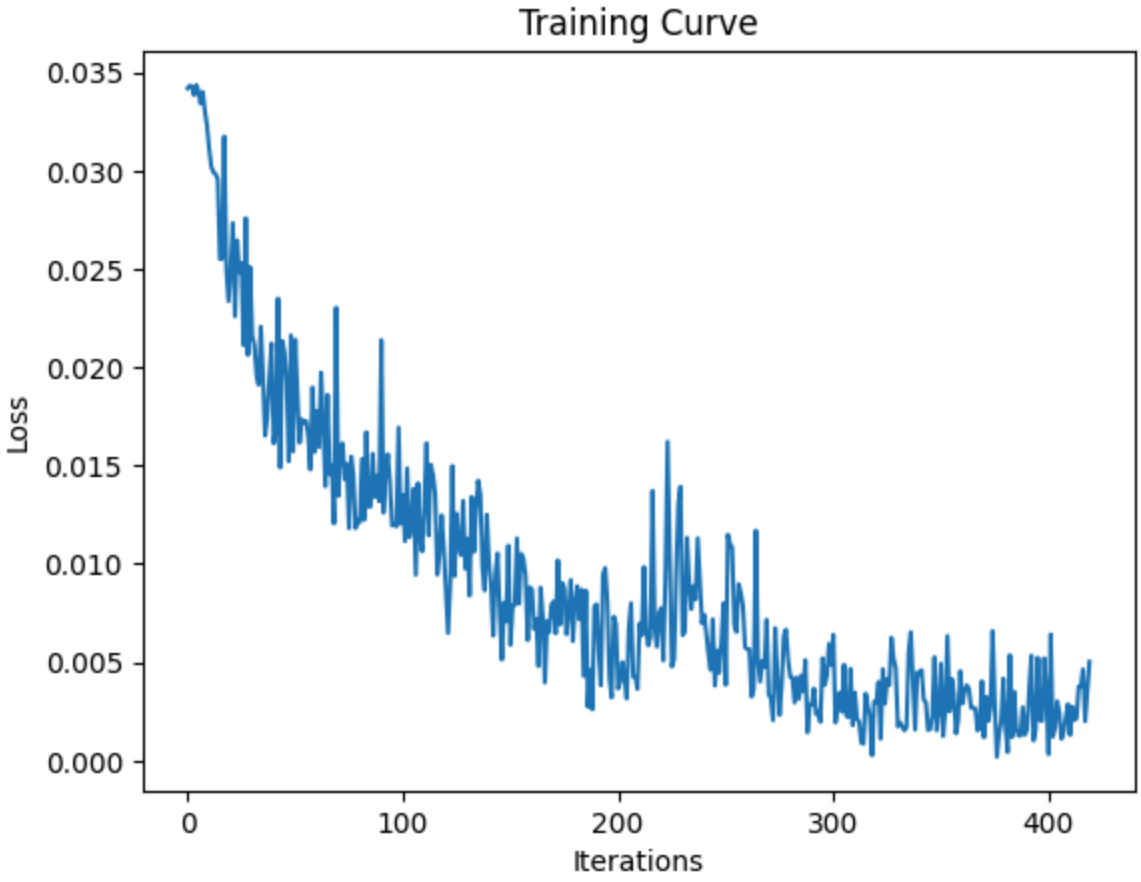
```
Iteration:  161 Progress:  38.33  % Time Elapsed:  1146.22 s
Iteration:  162 Progress:  38.57  % Time Elapsed:  1153.46 s
Iteration:  163 Progress:  38.81  % Time Elapsed:  1159.77 s
Iteration:  164 Progress:  39.05  % Time Elapsed:  1167.16 s
Iteration:  165 Progress:  39.29  % Time Elapsed:  1173.66 s
Iteration:  166 Progress:  39.52  % Time Elapsed:  1180.88 s
Iteration:  167 Progress:  39.76  % Time Elapsed:  1187.20 s
Iteration:  168 Progress:  40.00  % Time Elapsed:  1194.20 s
Epoch 7 Finished.  Time per Epoch:  149.27 s
Iteration:  169 Progress:  40.24  % Time Elapsed:  1200.64 s
Iteration:  170 Progress:  40.48  % Time Elapsed:  1208.00 s
Iteration:  171 Progress:  40.71  % Time Elapsed:  1214.36 s
Iteration:  172 Progress:  40.95  % Time Elapsed:  1221.77 s
Iteration:  173 Progress:  41.19  % Time Elapsed:  1228.28 s
Iteration:  174 Progress:  41.43  % Time Elapsed:  1235.74 s
Iteration:  175 Progress:  41.67  % Time Elapsed:  1242.21 s
Iteration:  176 Progress:  41.90  % Time Elapsed:  1249.65 s
Iteration:  177 Progress:  42.14  % Time Elapsed:  1256.17 s
Iteration:  178 Progress:  42.38  % Time Elapsed:  1263.43 s
Iteration:  179 Progress:  42.62  % Time Elapsed:  1269.94 s
Iteration:  180 Progress:  42.86  % Time Elapsed:  1277.28 s
Iteration:  181 Progress:  43.10  % Time Elapsed:  1283.82 s
Iteration:  182 Progress:  43.33  % Time Elapsed:  1291.22 s
Iteration:  183 Progress:  43.57  % Time Elapsed:  1297.76 s
Iteration:  184 Progress:  43.81  % Time Elapsed:  1305.08 s
Iteration:  185 Progress:  44.05  % Time Elapsed:  1311.59 s
Iteration:  186 Progress:  44.29  % Time Elapsed:  1319.11 s
Iteration:  187 Progress:  44.52  % Time Elapsed:  1325.83 s
Iteration:  188 Progress:  44.76  % Time Elapsed:  1333.24 s
Iteration:  189 Progress:  45.00  % Time Elapsed:  1339.26 s
Epoch 8 Finished.  Time per Epoch:  148.81 s
Iteration:  190 Progress:  45.24  % Time Elapsed:  1346.59 s
Iteration:  191 Progress:  45.48  % Time Elapsed:  1353.06 s
Iteration:  192 Progress:  45.71  % Time Elapsed:  1360.44 s
Iteration:  193 Progress:  45.95  % Time Elapsed:  1366.88 s
Iteration:  194 Progress:  46.19  % Time Elapsed:  1374.29 s
Iteration:  195 Progress:  46.43  % Time Elapsed:  1380.75 s
Iteration:  196 Progress:  46.67  % Time Elapsed:  1388.32 s
Iteration:  197 Progress:  46.90  % Time Elapsed:  1394.77 s
Iteration:  198 Progress:  47.14  % Time Elapsed:  1402.13 s
Iteration:  199 Progress:  47.38  % Time Elapsed:  1408.82 s
Iteration:  200 Progress:  47.62  % Time Elapsed:  1416.10 s
Iteration:  201 Progress:  47.86  % Time Elapsed:  1422.75 s
Iteration:  202 Progress:  48.10  % Time Elapsed:  1430.04 s
Iteration:  203 Progress:  48.33  % Time Elapsed:  1436.73 s
Iteration:  204 Progress:  48.57  % Time Elapsed:  1443.91 s
Iteration:  205 Progress:  48.81  % Time Elapsed:  1450.75 s
Iteration:  206 Progress:  49.05  % Time Elapsed:  1457.66 s
Iteration:  207 Progress:  49.29  % Time Elapsed:  1464.49 s
Iteration:  208 Progress:  49.52  % Time Elapsed:  1471.51 s
Iteration:  209 Progress:  49.76  % Time Elapsed:  1478.39 s
Iteration:  210 Progress:  50.00  % Time Elapsed:  1485.02 s
Epoch 9 Finished.  Time per Epoch:  148.50 s
Iteration:  211 Progress:  50.24  % Time Elapsed:  1491.92 s
Iteration:  212 Progress:  50.48  % Time Elapsed:  1499.05 s
Iteration:  213 Progress:  50.71  % Time Elapsed:  1505.95 s
```

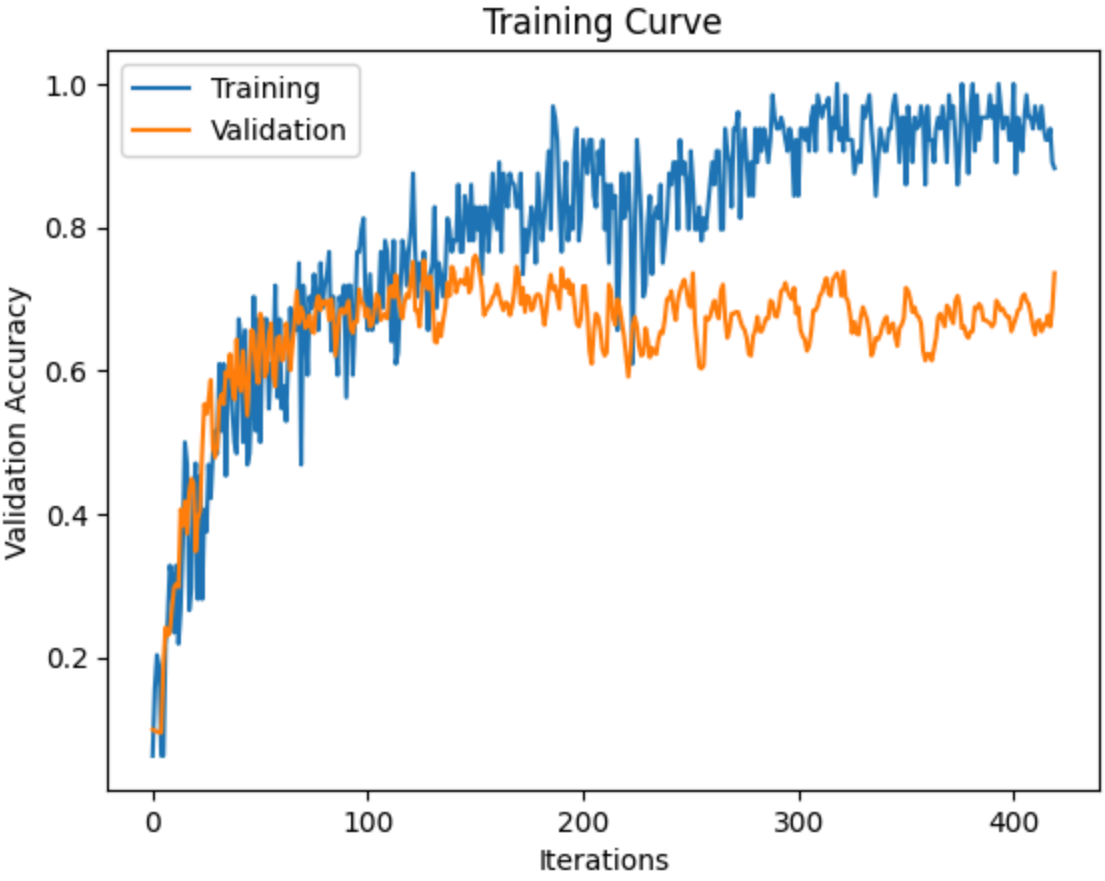
```
Iteration:  214 Progress:  50.95  % Time Elapsed:  1512.75 s
Iteration:  215 Progress:  51.19  % Time Elapsed:  1519.72 s
Iteration:  216 Progress:  51.43  % Time Elapsed:  1526.61 s
Iteration:  217 Progress:  51.67  % Time Elapsed:  1533.39 s
Iteration:  218 Progress:  51.90  % Time Elapsed:  1540.25 s
Iteration:  219 Progress:  52.14  % Time Elapsed:  1547.15 s
Iteration:  220 Progress:  52.38  % Time Elapsed:  1554.17 s
Iteration:  221 Progress:  52.62  % Time Elapsed:  1561.25 s
Iteration:  222 Progress:  52.86  % Time Elapsed:  1568.01 s
Iteration:  223 Progress:  53.10  % Time Elapsed:  1575.11 s
Iteration:  224 Progress:  53.33  % Time Elapsed:  1581.99 s
Iteration:  225 Progress:  53.57  % Time Elapsed:  1589.12 s
Iteration:  226 Progress:  53.81  % Time Elapsed:  1595.80 s
Iteration:  227 Progress:  54.05  % Time Elapsed:  1602.95 s
Iteration:  228 Progress:  54.29  % Time Elapsed:  1609.58 s
Iteration:  229 Progress:  54.52  % Time Elapsed:  1616.80 s
Iteration:  230 Progress:  54.76  % Time Elapsed:  1623.49 s
Iteration:  231 Progress:  55.00  % Time Elapsed:  1630.23 s
Epoch 10 Finished.  Time per Epoch:  148.20 s
Iteration:  232 Progress:  55.24  % Time Elapsed:  1637.05 s
Iteration:  233 Progress:  55.48  % Time Elapsed:  1644.13 s
Iteration:  234 Progress:  55.71  % Time Elapsed:  1650.83 s
Iteration:  235 Progress:  55.95  % Time Elapsed:  1658.10 s
Iteration:  236 Progress:  56.19  % Time Elapsed:  1664.83 s
Iteration:  237 Progress:  56.43  % Time Elapsed:  1672.19 s
Iteration:  238 Progress:  56.67  % Time Elapsed:  1678.83 s
Iteration:  239 Progress:  56.90  % Time Elapsed:  1686.30 s
Iteration:  240 Progress:  57.14  % Time Elapsed:  1692.88 s
Iteration:  241 Progress:  57.38  % Time Elapsed:  1700.36 s
Iteration:  242 Progress:  57.62  % Time Elapsed:  1707.00 s
Iteration:  243 Progress:  57.86  % Time Elapsed:  1714.52 s
Iteration:  244 Progress:  58.10  % Time Elapsed:  1721.08 s
Iteration:  245 Progress:  58.33  % Time Elapsed:  1728.42 s
Iteration:  246 Progress:  58.57  % Time Elapsed:  1735.08 s
Iteration:  247 Progress:  58.81  % Time Elapsed:  1742.40 s
Iteration:  248 Progress:  59.05  % Time Elapsed:  1748.99 s
Iteration:  249 Progress:  59.29  % Time Elapsed:  1756.39 s
Iteration:  250 Progress:  59.52  % Time Elapsed:  1762.87 s
Iteration:  251 Progress:  59.76  % Time Elapsed:  1770.19 s
Iteration:  252 Progress:  60.00  % Time Elapsed:  1776.34 s
Epoch 11 Finished.  Time per Epoch:  148.03 s
Iteration:  253 Progress:  60.24  % Time Elapsed:  1783.60 s
Iteration:  254 Progress:  60.48  % Time Elapsed:  1790.17 s
Iteration:  255 Progress:  60.71  % Time Elapsed:  1797.50 s
Iteration:  256 Progress:  60.95  % Time Elapsed:  1804.00 s
Iteration:  257 Progress:  61.19  % Time Elapsed:  1811.27 s
Iteration:  258 Progress:  61.43  % Time Elapsed:  1817.71 s
Iteration:  259 Progress:  61.67  % Time Elapsed:  1825.09 s
Iteration:  260 Progress:  61.90  % Time Elapsed:  1831.66 s
Iteration:  261 Progress:  62.14  % Time Elapsed:  1839.00 s
Iteration:  262 Progress:  62.38  % Time Elapsed:  1845.68 s
Iteration:  263 Progress:  62.62  % Time Elapsed:  1853.21 s
Iteration:  264 Progress:  62.86  % Time Elapsed:  1859.79 s
Iteration:  265 Progress:  63.10  % Time Elapsed:  1867.36 s
Iteration:  266 Progress:  63.33  % Time Elapsed:  1873.85 s
Iteration:  267 Progress:  63.57  % Time Elapsed:  1881.20 s
```

```
Iteration:  268 Progress:  63.81  % Time Elapsed:  1887.72 s
Iteration:  269 Progress:  64.05  % Time Elapsed:  1895.26 s
Iteration:  270 Progress:  64.29  % Time Elapsed:  1901.81 s
Iteration:  271 Progress:  64.52  % Time Elapsed:  1909.33 s
Iteration:  272 Progress:  64.76  % Time Elapsed:  1915.72 s
Iteration:  273 Progress:  65.00  % Time Elapsed:  1922.80 s
Epoch 12 Finished.  Time per Epoch:  147.91 s
Iteration:  274 Progress:  65.24  % Time Elapsed:  1929.39 s
Iteration:  275 Progress:  65.48  % Time Elapsed:  1936.91 s
Iteration:  276 Progress:  65.71  % Time Elapsed:  1943.38 s
Iteration:  277 Progress:  65.95  % Time Elapsed:  1950.85 s
Iteration:  278 Progress:  66.19  % Time Elapsed:  1957.69 s
Iteration:  279 Progress:  66.43  % Time Elapsed:  1965.06 s
Iteration:  280 Progress:  66.67  % Time Elapsed:  1972.88 s
Iteration:  281 Progress:  66.90  % Time Elapsed:  1979.81 s
Iteration:  282 Progress:  67.14  % Time Elapsed:  1986.95 s
Iteration:  283 Progress:  67.38  % Time Elapsed:  1993.95 s
Iteration:  284 Progress:  67.62  % Time Elapsed:  2001.53 s
Iteration:  285 Progress:  67.86  % Time Elapsed:  2008.30 s
Iteration:  286 Progress:  68.10  % Time Elapsed:  2015.57 s
Iteration:  287 Progress:  68.33  % Time Elapsed:  2022.30 s
Iteration:  288 Progress:  68.57  % Time Elapsed:  2029.93 s
Iteration:  289 Progress:  68.81  % Time Elapsed:  2036.43 s
Iteration:  290 Progress:  69.05  % Time Elapsed:  2043.96 s
Iteration:  291 Progress:  69.29  % Time Elapsed:  2050.48 s
Iteration:  292 Progress:  69.52  % Time Elapsed:  2057.91 s
Iteration:  293 Progress:  69.76  % Time Elapsed:  2064.37 s
Iteration:  294 Progress:  70.00  % Time Elapsed:  2071.29 s
Epoch 13 Finished.  Time per Epoch:  147.95 s
Iteration:  295 Progress:  70.24  % Time Elapsed:  2077.88 s
Iteration:  296 Progress:  70.48  % Time Elapsed:  2085.23 s
Iteration:  297 Progress:  70.71  % Time Elapsed:  2091.79 s
Iteration:  298 Progress:  70.95  % Time Elapsed:  2099.02 s
Iteration:  299 Progress:  71.19  % Time Elapsed:  2105.61 s
Iteration:  300 Progress:  71.43  % Time Elapsed:  2112.92 s
Iteration:  301 Progress:  71.67  % Time Elapsed:  2119.42 s
Iteration:  302 Progress:  71.90  % Time Elapsed:  2126.82 s
Iteration:  303 Progress:  72.14  % Time Elapsed:  2133.26 s
Iteration:  304 Progress:  72.38  % Time Elapsed:  2140.54 s
Iteration:  305 Progress:  72.62  % Time Elapsed:  2146.95 s
Iteration:  306 Progress:  72.86  % Time Elapsed:  2154.35 s
Iteration:  307 Progress:  73.10  % Time Elapsed:  2160.87 s
Iteration:  308 Progress:  73.33  % Time Elapsed:  2168.23 s
Iteration:  309 Progress:  73.57  % Time Elapsed:  2174.81 s
Iteration:  310 Progress:  73.81  % Time Elapsed:  2182.17 s
Iteration:  311 Progress:  74.05  % Time Elapsed:  2188.74 s
Iteration:  312 Progress:  74.29  % Time Elapsed:  2196.13 s
Iteration:  313 Progress:  74.52  % Time Elapsed:  2202.67 s
Iteration:  314 Progress:  74.76  % Time Elapsed:  2210.06 s
Iteration:  315 Progress:  75.00  % Time Elapsed:  2216.21 s
Epoch 14 Finished.  Time per Epoch:  147.75 s
Iteration:  316 Progress:  75.24  % Time Elapsed:  2223.58 s
Iteration:  317 Progress:  75.48  % Time Elapsed:  2230.12 s
Iteration:  318 Progress:  75.71  % Time Elapsed:  2237.44 s
Iteration:  319 Progress:  75.95  % Time Elapsed:  2243.85 s
Iteration:  320 Progress:  76.19  % Time Elapsed:  2251.33 s
```

```
Iteration:  321 Progress:  76.43  % Time Elapsed:  2257.90 s
Iteration:  322 Progress:  76.67  % Time Elapsed:  2265.27 s
Iteration:  323 Progress:  76.90  % Time Elapsed:  2271.84 s
Iteration:  324 Progress:  77.14  % Time Elapsed:  2279.11 s
Iteration:  325 Progress:  77.38  % Time Elapsed:  2285.60 s
Iteration:  326 Progress:  77.62  % Time Elapsed:  2292.94 s
Iteration:  327 Progress:  77.86  % Time Elapsed:  2299.42 s
Iteration:  328 Progress:  78.10  % Time Elapsed:  2306.82 s
Iteration:  329 Progress:  78.33  % Time Elapsed:  2313.34 s
Iteration:  330 Progress:  78.57  % Time Elapsed:  2320.72 s
Iteration:  331 Progress:  78.81  % Time Elapsed:  2327.19 s
Iteration:  332 Progress:  79.05  % Time Elapsed:  2334.74 s
Iteration:  333 Progress:  79.29  % Time Elapsed:  2341.25 s
Iteration:  334 Progress:  79.52  % Time Elapsed:  2348.72 s
Iteration:  335 Progress:  79.76  % Time Elapsed:  2355.17 s
Iteration:  336 Progress:  80.00  % Time Elapsed:  2362.26 s
Epoch 15 Finished.  Time per Epoch:  147.64 s
Iteration:  337 Progress:  80.24  % Time Elapsed:  2368.63 s
Iteration:  338 Progress:  80.48  % Time Elapsed:  2376.07 s
Iteration:  339 Progress:  80.71  % Time Elapsed:  2382.54 s
Iteration:  340 Progress:  80.95  % Time Elapsed:  2390.06 s
Iteration:  341 Progress:  81.19  % Time Elapsed:  2396.61 s
Iteration:  342 Progress:  81.43  % Time Elapsed:  2403.98 s
Iteration:  343 Progress:  81.67  % Time Elapsed:  2410.81 s
Iteration:  344 Progress:  81.90  % Time Elapsed:  2418.05 s
Iteration:  345 Progress:  82.14  % Time Elapsed:  2424.98 s
Iteration:  346 Progress:  82.38  % Time Elapsed:  2432.15 s
Iteration:  347 Progress:  82.62  % Time Elapsed:  2439.21 s
Iteration:  348 Progress:  82.86  % Time Elapsed:  2446.43 s
Iteration:  349 Progress:  83.10  % Time Elapsed:  2453.86 s
Iteration:  350 Progress:  83.33  % Time Elapsed:  2460.83 s
Iteration:  351 Progress:  83.57  % Time Elapsed:  2468.60 s
Iteration:  352 Progress:  83.81  % Time Elapsed:  2475.28 s
Iteration:  353 Progress:  84.05  % Time Elapsed:  2482.89 s
Iteration:  354 Progress:  84.29  % Time Elapsed:  2489.59 s
Iteration:  355 Progress:  84.52  % Time Elapsed:  2496.96 s
Iteration:  356 Progress:  84.76  % Time Elapsed:  2503.49 s
Iteration:  357 Progress:  85.00  % Time Elapsed:  2510.43 s
Epoch 16 Finished.  Time per Epoch:  147.67 s
Iteration:  358 Progress:  85.24  % Time Elapsed:  2516.95 s
Iteration:  359 Progress:  85.48  % Time Elapsed:  2524.38 s
Iteration:  360 Progress:  85.71  % Time Elapsed:  2530.84 s
Iteration:  361 Progress:  85.95  % Time Elapsed:  2538.24 s
Iteration:  362 Progress:  86.19  % Time Elapsed:  2544.95 s
Iteration:  363 Progress:  86.43  % Time Elapsed:  2552.37 s
Iteration:  364 Progress:  86.67  % Time Elapsed:  2558.96 s
Iteration:  365 Progress:  86.90  % Time Elapsed:  2566.53 s
Iteration:  366 Progress:  87.14  % Time Elapsed:  2573.43 s
Iteration:  367 Progress:  87.38  % Time Elapsed:  2580.72 s
Iteration:  368 Progress:  87.62  % Time Elapsed:  2587.94 s
Iteration:  369 Progress:  87.86  % Time Elapsed:  2595.23 s
Iteration:  370 Progress:  88.10  % Time Elapsed:  2602.92 s
Iteration:  371 Progress:  88.33  % Time Elapsed:  2609.60 s
Iteration:  372 Progress:  88.57  % Time Elapsed:  2617.27 s
Iteration:  373 Progress:  88.81  % Time Elapsed:  2624.21 s
Iteration:  374 Progress:  89.05  % Time Elapsed:  2631.91 s
```

```
Iteration:  375 Progress:  89.29  % Time Elapsed:  2638.79 s
Iteration:  376 Progress:  89.52  % Time Elapsed:  2646.33 s
Iteration:  377 Progress:  89.76  % Time Elapsed:  2653.10 s
Iteration:  378 Progress:  90.00  % Time Elapsed:  2660.20 s
Epoch 17 Finished.  Time per Epoch:  147.79 s
Iteration:  379 Progress:  90.24  % Time Elapsed:  2666.89 s
Iteration:  380 Progress:  90.48  % Time Elapsed:  2674.30 s
Iteration:  381 Progress:  90.71  % Time Elapsed:  2681.14 s
Iteration:  382 Progress:  90.95  % Time Elapsed:  2688.58 s
Iteration:  383 Progress:  91.19  % Time Elapsed:  2696.14 s
Iteration:  384 Progress:  91.43  % Time Elapsed:  2703.18 s
Iteration:  385 Progress:  91.67  % Time Elapsed:  2710.76 s
Iteration:  386 Progress:  91.90  % Time Elapsed:  2717.30 s
Iteration:  387 Progress:  92.14  % Time Elapsed:  2724.94 s
Iteration:  388 Progress:  92.38  % Time Elapsed:  2731.53 s
Iteration:  389 Progress:  92.62  % Time Elapsed:  2739.02 s
Iteration:  390 Progress:  92.86  % Time Elapsed:  2745.76 s
Iteration:  391 Progress:  93.10  % Time Elapsed:  2753.34 s
Iteration:  392 Progress:  93.33  % Time Elapsed:  2760.06 s
Iteration:  393 Progress:  93.57  % Time Elapsed:  2767.40 s
Iteration:  394 Progress:  93.81  % Time Elapsed:  2774.11 s
Iteration:  395 Progress:  94.05  % Time Elapsed:  2781.62 s
Iteration:  396 Progress:  94.29  % Time Elapsed:  2788.51 s
Iteration:  397 Progress:  94.52  % Time Elapsed:  2795.96 s
Iteration:  398 Progress:  94.76  % Time Elapsed:  2802.87 s
Iteration:  399 Progress:  95.00  % Time Elapsed:  2809.67 s
Epoch 18 Finished.  Time per Epoch:  147.88 s
Iteration:  400 Progress:  95.24  % Time Elapsed:  2816.77 s
Iteration:  401 Progress:  95.48  % Time Elapsed:  2823.93 s
Iteration:  402 Progress:  95.71  % Time Elapsed:  2831.05 s
Iteration:  403 Progress:  95.95  % Time Elapsed:  2837.86 s
Iteration:  404 Progress:  96.19  % Time Elapsed:  2845.43 s
Iteration:  405 Progress:  96.43  % Time Elapsed:  2852.11 s
Iteration:  406 Progress:  96.67  % Time Elapsed:  2859.56 s
Iteration:  407 Progress:  96.90  % Time Elapsed:  2866.20 s
Iteration:  408 Progress:  97.14  % Time Elapsed:  2873.77 s
Iteration:  409 Progress:  97.38  % Time Elapsed:  2880.45 s
Iteration:  410 Progress:  97.62  % Time Elapsed:  2887.93 s
Iteration:  411 Progress:  97.86  % Time Elapsed:  2894.48 s
Iteration:  412 Progress:  98.10  % Time Elapsed:  2901.91 s
Iteration:  413 Progress:  98.33  % Time Elapsed:  2908.53 s
Iteration:  414 Progress:  98.57  % Time Elapsed:  2915.89 s
Iteration:  415 Progress:  98.81  % Time Elapsed:  2922.67 s
Iteration:  416 Progress:  99.05  % Time Elapsed:  2930.30 s
Iteration:  417 Progress:  99.29  % Time Elapsed:  2937.39 s
Iteration:  418 Progress:  99.52  % Time Elapsed:  2944.88 s
Iteration:  419 Progress:  99.76  % Time Elapsed:  2952.27 s
Iteration:  420 Progress:  100.00  % Time Elapsed:  2958.91 s
Epoch 19 Finished.  Time per Epoch:  147.95 s
```


Training Curve
Loss
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
100
200
300
400
Iterations


Training Curve
Training
Validation
Validation Accuracy
1.0
0.8
0.6
0.4
0.2
0
100
200
300
400
Iterations

```
Final Training Accuracy: 0.9691960931630353
Final Validation Accuracy: 0.7358916478555305
Total time:   2958.91 s  Time per Epoch:  147.95 s
```

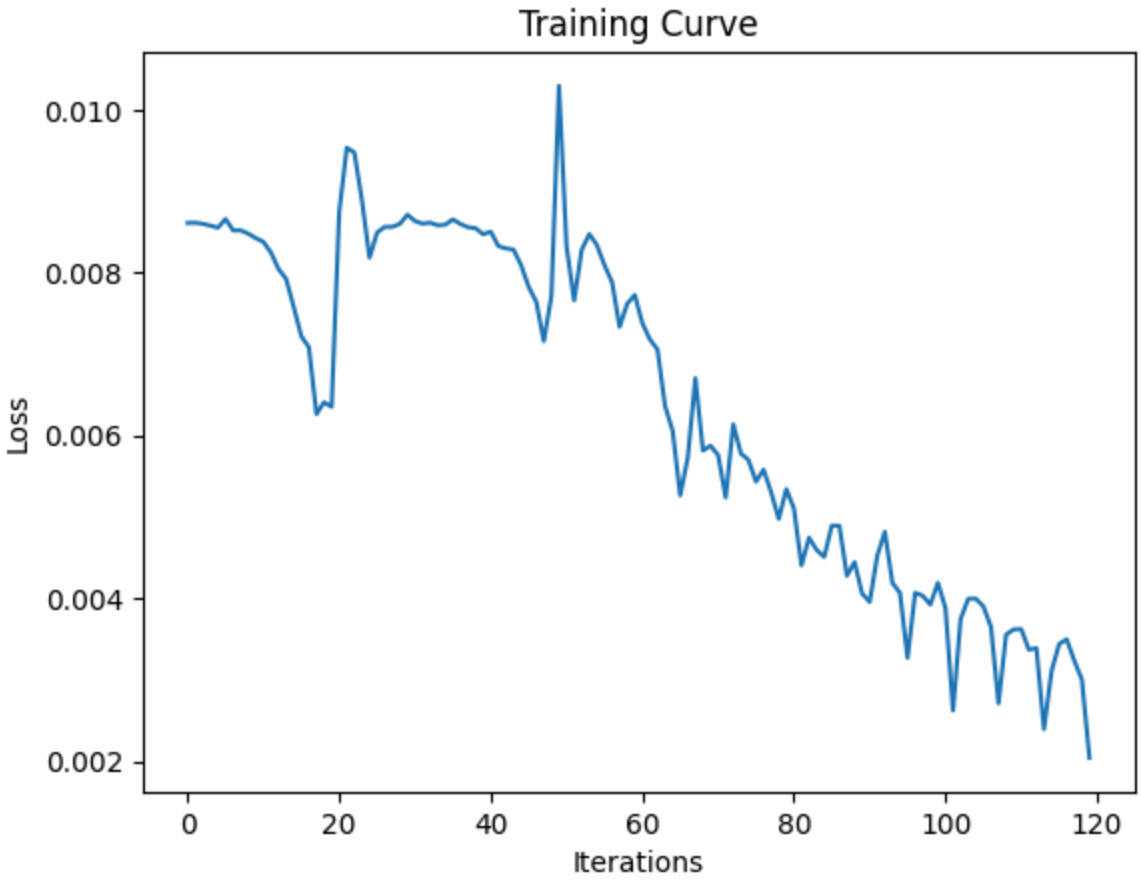
In [ ]:

```python
#Batch Size changed to 256
use_cuda = True
model = Gesture_CNN()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')


train(model,train_dataset,batch_size=256, num_epochs=20, lr=0.02)
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.83  % Time Elapsed:  12.70 s
Iteration:  2 Progress:   1.67  % Time Elapsed:  24.33 s
Iteration:  3 Progress:   2.50  % Time Elapsed:  36.31 s
Iteration:  4 Progress:   3.33  % Time Elapsed:  48.75 s
Iteration:  5 Progress:   4.17  % Time Elapsed:  62.52 s
Iteration:  6 Progress:   5.00  % Time Elapsed:  70.17 s
Epoch 0 Finished.  Time per Epoch:  70.17 s
Iteration:  7 Progress:   5.83  % Time Elapsed:  82.64 s
Iteration:  8 Progress:   6.67  % Time Elapsed:  94.62 s
Iteration:  9 Progress:   7.50  % Time Elapsed:  106.36 s
Iteration:  10 Progress:   8.33  % Time Elapsed:  118.61 s
Iteration:  11 Progress:   9.17  % Time Elapsed:  131.06 s
Iteration:  12 Progress:  10.00  % Time Elapsed:  138.75 s
Epoch 1 Finished.  Time per Epoch:  69.38 s
Iteration:  13 Progress:  10.83  % Time Elapsed:  151.08 s
Iteration:  14 Progress:  11.67  % Time Elapsed:  163.11 s
Iteration:  15 Progress:  12.50  % Time Elapsed:  174.78 s
Iteration:  16 Progress:  13.33  % Time Elapsed:  187.03 s
Iteration:  17 Progress:  14.17  % Time Elapsed:  199.60 s
Iteration:  18 Progress:  15.00  % Time Elapsed:  207.19 s
Epoch 2 Finished.  Time per Epoch:  69.06 s
Iteration:  19 Progress:  15.83  % Time Elapsed:  219.46 s
Iteration:  20 Progress:  16.67  % Time Elapsed:  231.51 s
Iteration:  21 Progress:  17.50  % Time Elapsed:  243.14 s
Iteration:  22 Progress:  18.33  % Time Elapsed:  255.39 s
Iteration:  23 Progress:  19.17  % Time Elapsed:  267.95 s
Iteration:  24 Progress:  20.00  % Time Elapsed:  275.67 s
Epoch 3 Finished.  Time per Epoch:  68.92 s
Iteration:  25 Progress:  20.83  % Time Elapsed:  288.05 s
Iteration:  26 Progress:  21.67  % Time Elapsed:  299.96 s
Iteration:  27 Progress:  22.50  % Time Elapsed:  311.59 s
Iteration:  28 Progress:  23.33  % Time Elapsed:  323.72 s
Iteration:  29 Progress:  24.17  % Time Elapsed:  336.01 s
Iteration:  30 Progress:  25.00  % Time Elapsed:  343.60 s
Epoch 4 Finished.  Time per Epoch:  68.72 s
Iteration:  31 Progress:  25.83  % Time Elapsed:  355.75 s
Iteration:  32 Progress:  26.67  % Time Elapsed:  367.59 s
Iteration:  33 Progress:  27.50  % Time Elapsed:  379.22 s
Iteration:  34 Progress:  28.33  % Time Elapsed:  391.42 s
Iteration:  35 Progress:  29.17  % Time Elapsed:  403.89 s
Iteration:  36 Progress:  30.00  % Time Elapsed:  411.38 s
Epoch 5 Finished.  Time per Epoch:  68.56 s
Iteration:  37 Progress:  30.83  % Time Elapsed:  423.22 s
Iteration:  38 Progress:  31.67  % Time Elapsed:  434.72 s
Iteration:  39 Progress:  32.50  % Time Elapsed:  446.78 s
Iteration:  40 Progress:  33.33  % Time Elapsed:  459.67 s
Iteration:  41 Progress:  34.17  % Time Elapsed:  475.92 s
Iteration:  42 Progress:  35.00  % Time Elapsed:  483.45 s
Epoch 6 Finished.  Time per Epoch:  69.06 s
Iteration:  43 Progress:  35.83  % Time Elapsed:  495.58 s
Iteration:  44 Progress:  36.67  % Time Elapsed:  507.72 s
Iteration:  45 Progress:  37.50  % Time Elapsed:  519.66 s
Iteration:  46 Progress:  38.33  % Time Elapsed:  531.89 s
Iteration:  47 Progress:  39.17  % Time Elapsed:  543.59 s
Iteration:  48 Progress:  40.00  % Time Elapsed:  551.05 s
```

```
Epoch 7 Finished.  Time per Epoch:  68.88 s
Iteration:  49 Progress:  40.83  % Time Elapsed:  563.22 s
Iteration:  50 Progress:  41.67  % Time Elapsed:  575.27 s
Iteration:  51 Progress:  42.50  % Time Elapsed:  586.93 s
Iteration:  52 Progress:  43.33  % Time Elapsed:  598.69 s
Iteration:  53 Progress:  44.17  % Time Elapsed:  611.04 s
Iteration:  54 Progress:  45.00  % Time Elapsed:  619.93 s
Epoch 8 Finished.  Time per Epoch:  68.88 s
Iteration:  55 Progress:  45.83  % Time Elapsed:  636.64 s
Iteration:  56 Progress:  46.67  % Time Elapsed:  648.78 s
Iteration:  57 Progress:  47.50  % Time Elapsed:  662.27 s
Iteration:  58 Progress:  48.33  % Time Elapsed:  674.47 s
Iteration:  59 Progress:  49.17  % Time Elapsed:  686.62 s
Iteration:  60 Progress:  50.00  % Time Elapsed:  693.12 s
Epoch 9 Finished.  Time per Epoch:  69.31 s
Iteration:  61 Progress:  50.83  % Time Elapsed:  705.95 s
Iteration:  62 Progress:  51.67  % Time Elapsed:  717.87 s
Iteration:  63 Progress:  52.50  % Time Elapsed:  729.85 s
Iteration:  64 Progress:  53.33  % Time Elapsed:  741.81 s
Iteration:  65 Progress:  54.17  % Time Elapsed:  753.52 s
Iteration:  66 Progress:  55.00  % Time Elapsed:  760.39 s
Epoch 10 Finished.  Time per Epoch:  69.13 s
Iteration:  67 Progress:  55.83  % Time Elapsed:  772.22 s
Iteration:  68 Progress:  56.67  % Time Elapsed:  784.19 s
Iteration:  69 Progress:  57.50  % Time Elapsed:  796.11 s
Iteration:  70 Progress:  58.33  % Time Elapsed:  807.63 s
Iteration:  71 Progress:  59.17  % Time Elapsed:  818.98 s
Iteration:  72 Progress:  60.00  % Time Elapsed:  826.24 s
Epoch 11 Finished.  Time per Epoch:  68.85 s
Iteration:  73 Progress:  60.83  % Time Elapsed:  838.18 s
Iteration:  74 Progress:  61.67  % Time Elapsed:  850.06 s
Iteration:  75 Progress:  62.50  % Time Elapsed:  861.41 s
Iteration:  76 Progress:  63.33  % Time Elapsed:  873.11 s
Iteration:  77 Progress:  64.17  % Time Elapsed:  885.38 s
Iteration:  78 Progress:  65.00  % Time Elapsed:  892.78 s
Epoch 12 Finished.  Time per Epoch:  68.68 s
Iteration:  79 Progress:  65.83  % Time Elapsed:  904.43 s
Iteration:  80 Progress:  66.67  % Time Elapsed:  915.76 s
Iteration:  81 Progress:  67.50  % Time Elapsed:  927.59 s
Iteration:  82 Progress:  68.33  % Time Elapsed:  939.95 s
Iteration:  83 Progress:  69.17  % Time Elapsed:  952.09 s
Iteration:  84 Progress:  70.00  % Time Elapsed:  959.21 s
Epoch 13 Finished.  Time per Epoch:  68.51 s
Iteration:  85 Progress:  70.83  % Time Elapsed:  970.42 s
Iteration:  86 Progress:  71.67  % Time Elapsed:  982.31 s
Iteration:  87 Progress:  72.50  % Time Elapsed:  994.70 s
Iteration:  88 Progress:  73.33  % Time Elapsed:  1006.87 s
Iteration:  89 Progress:  74.17  % Time Elapsed:  1018.71 s
Iteration:  90 Progress:  75.00  % Time Elapsed:  1025.20 s
Epoch 14 Finished.  Time per Epoch:  68.35 s
Iteration:  91 Progress:  75.83  % Time Elapsed:  1037.15 s
Iteration:  92 Progress:  76.67  % Time Elapsed:  1050.24 s
Iteration:  93 Progress:  77.50  % Time Elapsed:  1062.46 s
Iteration:  94 Progress:  78.33  % Time Elapsed:  1074.45 s
Iteration:  95 Progress:  79.17  % Time Elapsed:  1086.48 s
Iteration:  96 Progress:  80.00  % Time Elapsed:  1092.95 s
```

```
Epoch 15 Finished.  Time per Epoch:  68.31 s
Iteration:  97 Progress:  80.83  % Time Elapsed:  1105.18 s
Iteration:  98 Progress:  81.67  % Time Elapsed:  1117.28 s
Iteration:  99 Progress:  82.50  % Time Elapsed:  1129.08 s
Iteration:  100 Progress:  83.33  % Time Elapsed:  1141.09 s
Iteration:  101 Progress:  84.17  % Time Elapsed:  1153.04 s
Iteration:  102 Progress:  85.00  % Time Elapsed:  1159.56 s
Epoch 16 Finished.  Time per Epoch:  68.21 s
Iteration:  103 Progress:  85.83  % Time Elapsed:  1171.43 s
Iteration:  104 Progress:  86.67  % Time Elapsed:  1183.33 s
Iteration:  105 Progress:  87.50  % Time Elapsed:  1195.37 s
Iteration:  106 Progress:  88.33  % Time Elapsed:  1207.02 s
Iteration:  107 Progress:  89.17  % Time Elapsed:  1218.16 s
Iteration:  108 Progress:  90.00  % Time Elapsed:  1225.44 s
Epoch 17 Finished.  Time per Epoch:  68.08 s
Iteration:  109 Progress:  90.83  % Time Elapsed:  1237.48 s
Iteration:  110 Progress:  91.67  % Time Elapsed:  1249.45 s
Iteration:  111 Progress:  92.50  % Time Elapsed:  1260.97 s
Iteration:  112 Progress:  93.33  % Time Elapsed:  1272.50 s
Iteration:  113 Progress:  94.17  % Time Elapsed:  1284.56 s
Iteration:  114 Progress:  95.00  % Time Elapsed:  1291.93 s
Epoch 18 Finished.  Time per Epoch:  68.00 s
Iteration:  115 Progress:  95.83  % Time Elapsed:  1303.83 s
Iteration:  116 Progress:  96.67  % Time Elapsed:  1315.43 s
Iteration:  117 Progress:  97.50  % Time Elapsed:  1326.89 s
Iteration:  118 Progress:  98.33  % Time Elapsed:  1339.03 s
Iteration:  119 Progress:  99.17  % Time Elapsed:  1351.16 s
Iteration:  120 Progress:  100.00  % Time Elapsed:  1358.42 s
Epoch 19 Finished.  Time per Epoch:  67.92 s
```



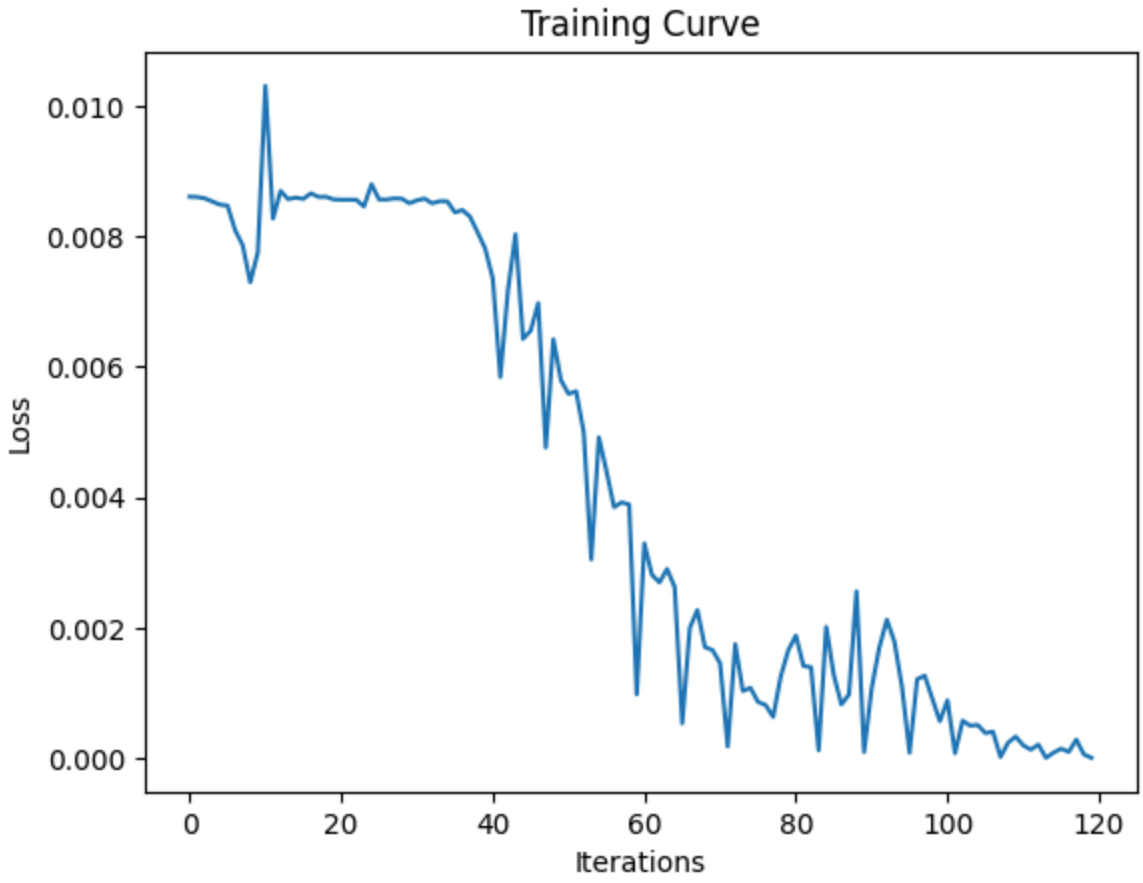

```
Final Training Accuracy: 0.7182569496619083
Final Validation Accuracy: 0.6952595936794582
Total time:   1358.42 s  Time per Epoch:  67.92 s
```

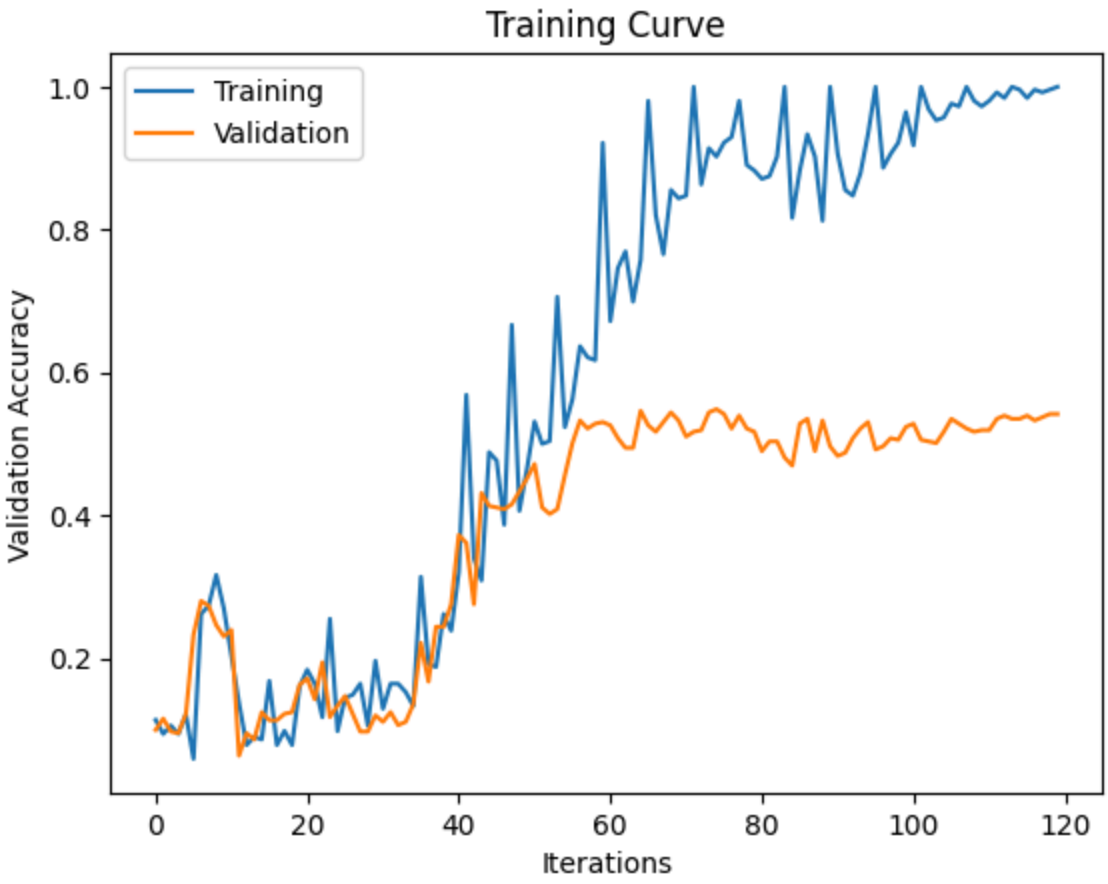
In [ ]:
```
#lr change to 0.07
use_cuda = True
model = Gesture_CNN()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')

train(model,train_dataset,batch_size=256, num_epochs=20, lr=0.07)
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.83  % Time Elapsed:  12.19 s
Iteration:  2 Progress:   1.67  % Time Elapsed:  24.50 s
Iteration:  3 Progress:   2.50  % Time Elapsed:  36.72 s
Iteration:  4 Progress:   3.33  % Time Elapsed:  48.86 s
Iteration:  5 Progress:   4.17  % Time Elapsed:  60.60 s
Iteration:  6 Progress:   5.00  % Time Elapsed:  67.81 s
Epoch 0 Finished.  Time per Epoch:  67.81 s
Iteration:  7 Progress:   5.83  % Time Elapsed:  80.18 s
Iteration:  8 Progress:   6.67  % Time Elapsed:  92.61 s
Iteration:  9 Progress:   7.50  % Time Elapsed:  104.95 s
Iteration:  10 Progress:   8.33  % Time Elapsed:  117.11 s
Iteration:  11 Progress:   9.17  % Time Elapsed:  128.77 s
Iteration:  12 Progress:  10.00  % Time Elapsed:  136.04 s
Epoch 1 Finished.  Time per Epoch:  68.02 s
Iteration:  13 Progress:  10.83  % Time Elapsed:  148.22 s
Iteration:  14 Progress:  11.67  % Time Elapsed:  160.47 s
Iteration:  15 Progress:  12.50  % Time Elapsed:  172.62 s
Iteration:  16 Progress:  13.33  % Time Elapsed:  184.43 s
Iteration:  17 Progress:  14.17  % Time Elapsed:  196.23 s
Iteration:  18 Progress:  15.00  % Time Elapsed:  203.68 s
Epoch 2 Finished.  Time per Epoch:  67.89 s
Iteration:  19 Progress:  15.83  % Time Elapsed:  215.94 s
Iteration:  20 Progress:  16.67  % Time Elapsed:  228.14 s
Iteration:  21 Progress:  17.50  % Time Elapsed:  240.06 s
Iteration:  22 Progress:  18.33  % Time Elapsed:  251.56 s
Iteration:  23 Progress:  19.17  % Time Elapsed:  263.68 s
Iteration:  24 Progress:  20.00  % Time Elapsed:  271.47 s
Epoch 3 Finished.  Time per Epoch:  67.87 s
Iteration:  25 Progress:  20.83  % Time Elapsed:  283.59 s
Iteration:  26 Progress:  21.67  % Time Elapsed:  295.49 s
Iteration:  27 Progress:  22.50  % Time Elapsed:  306.92 s
Iteration:  28 Progress:  23.33  % Time Elapsed:  318.88 s
Iteration:  29 Progress:  24.17  % Time Elapsed:  331.26 s
Iteration:  30 Progress:  25.00  % Time Elapsed:  338.79 s
Epoch 4 Finished.  Time per Epoch:  67.76 s
Iteration:  31 Progress:  25.83  % Time Elapsed:  350.78 s
Iteration:  32 Progress:  26.67  % Time Elapsed:  362.32 s
Iteration:  33 Progress:  27.50  % Time Elapsed:  374.13 s
Iteration:  34 Progress:  28.33  % Time Elapsed:  386.44 s
Iteration:  35 Progress:  29.17  % Time Elapsed:  398.96 s
Iteration:  36 Progress:  30.00  % Time Elapsed:  406.61 s
Epoch 5 Finished.  Time per Epoch:  67.77 s
Iteration:  37 Progress:  30.83  % Time Elapsed:  418.49 s
Iteration:  38 Progress:  31.67  % Time Elapsed:  429.99 s
Iteration:  39 Progress:  32.50  % Time Elapsed:  442.12 s
Iteration:  40 Progress:  33.33  % Time Elapsed:  454.60 s
Iteration:  41 Progress:  34.17  % Time Elapsed:  467.14 s
Iteration:  42 Progress:  35.00  % Time Elapsed:  474.58 s
Epoch 6 Finished.  Time per Epoch:  67.80 s
Iteration:  43 Progress:  35.83  % Time Elapsed:  486.36 s
Iteration:  44 Progress:  36.67  % Time Elapsed:  498.17 s
Iteration:  45 Progress:  37.50  % Time Elapsed:  510.40 s
Iteration:  46 Progress:  38.33  % Time Elapsed:  522.86 s
Iteration:  47 Progress:  39.17  % Time Elapsed:  535.16 s
Iteration:  48 Progress:  40.00  % Time Elapsed:  544.38 s
```

```
Epoch 7 Finished.  Time per Epoch:  68.05 s
Iteration:  49 Progress:  40.83  % Time Elapsed:  556.19 s
Iteration:  50 Progress:  41.67  % Time Elapsed:  567.75 s
Iteration:  51 Progress:  42.50  % Time Elapsed:  579.79 s
Iteration:  52 Progress:  43.33  % Time Elapsed:  592.15 s
Iteration:  53 Progress:  44.17  % Time Elapsed:  604.55 s
Iteration:  54 Progress:  45.00  % Time Elapsed:  612.00 s
Epoch 8 Finished.  Time per Epoch:  68.00 s
Iteration:  55 Progress:  45.83  % Time Elapsed:  623.64 s
Iteration:  56 Progress:  46.67  % Time Elapsed:  635.26 s
Iteration:  57 Progress:  47.50  % Time Elapsed:  648.20 s
Iteration:  58 Progress:  48.33  % Time Elapsed:  660.59 s
Iteration:  59 Progress:  49.17  % Time Elapsed:  673.09 s
Iteration:  60 Progress:  50.00  % Time Elapsed:  680.50 s
Epoch 9 Finished.  Time per Epoch:  68.05 s
Iteration:  61 Progress:  50.83  % Time Elapsed:  692.03 s
Iteration:  62 Progress:  51.67  % Time Elapsed:  703.83 s
Iteration:  63 Progress:  52.50  % Time Elapsed:  716.11 s
Iteration:  64 Progress:  53.33  % Time Elapsed:  728.46 s
Iteration:  65 Progress:  54.17  % Time Elapsed:  740.60 s
Iteration:  66 Progress:  55.00  % Time Elapsed:  747.68 s
Epoch 10 Finished.  Time per Epoch:  67.97 s
Iteration:  67 Progress:  55.83  % Time Elapsed:  759.24 s
Iteration:  68 Progress:  56.67  % Time Elapsed:  771.52 s
Iteration:  69 Progress:  57.50  % Time Elapsed:  783.86 s
Iteration:  70 Progress:  58.33  % Time Elapsed:  796.15 s
Iteration:  71 Progress:  59.17  % Time Elapsed:  808.24 s
Iteration:  72 Progress:  60.00  % Time Elapsed:  814.76 s
Epoch 11 Finished.  Time per Epoch:  67.90 s
Iteration:  73 Progress:  60.83  % Time Elapsed:  826.77 s
Iteration:  74 Progress:  61.67  % Time Elapsed:  839.19 s
Iteration:  75 Progress:  62.50  % Time Elapsed:  854.87 s
Iteration:  76 Progress:  63.33  % Time Elapsed:  867.39 s
Iteration:  77 Progress:  64.17  % Time Elapsed:  879.73 s
Iteration:  78 Progress:  65.00  % Time Elapsed:  887.08 s
Epoch 12 Finished.  Time per Epoch:  68.24 s
Iteration:  79 Progress:  65.83  % Time Elapsed:  898.65 s
Iteration:  80 Progress:  66.67  % Time Elapsed:  910.41 s
Iteration:  81 Progress:  67.50  % Time Elapsed:  922.72 s
Iteration:  82 Progress:  68.33  % Time Elapsed:  935.16 s
Iteration:  83 Progress:  69.17  % Time Elapsed:  947.42 s
Iteration:  84 Progress:  70.00  % Time Elapsed:  954.67 s
Epoch 13 Finished.  Time per Epoch:  68.19 s
Iteration:  85 Progress:  70.83  % Time Elapsed:  966.22 s
Iteration:  86 Progress:  71.67  % Time Elapsed:  978.35 s
Iteration:  87 Progress:  72.50  % Time Elapsed:  990.84 s
Iteration:  88 Progress:  73.33  % Time Elapsed:  1003.30 s
Iteration:  89 Progress:  74.17  % Time Elapsed:  1015.35 s
Iteration:  90 Progress:  75.00  % Time Elapsed:  1022.24 s
Epoch 14 Finished.  Time per Epoch:  68.15 s
Iteration:  91 Progress:  75.83  % Time Elapsed:  1034.03 s
Iteration:  92 Progress:  76.67  % Time Elapsed:  1046.40 s
Iteration:  93 Progress:  77.50  % Time Elapsed:  1058.79 s
Iteration:  94 Progress:  78.33  % Time Elapsed:  1071.13 s
Iteration:  95 Progress:  79.17  % Time Elapsed:  1083.03 s
Iteration:  96 Progress:  80.00  % Time Elapsed:  1089.57 s
```

```
Epoch 15 Finished.  Time per Epoch:  68.10 s
Iteration:  97 Progress:  80.83  % Time Elapsed:  1101.82 s
Iteration:  98 Progress:  81.67  % Time Elapsed:  1114.37 s
Iteration:  99 Progress:  82.50  % Time Elapsed:  1126.63 s
Iteration:  100 Progress:  83.33  % Time Elapsed:  1138.61 s
Iteration:  101 Progress:  84.17  % Time Elapsed:  1150.82 s
Iteration:  102 Progress:  85.00  % Time Elapsed:  1157.49 s
Epoch 16 Finished.  Time per Epoch:  68.09 s
Iteration:  103 Progress:  85.83  % Time Elapsed:  1169.89 s
Iteration:  104 Progress:  86.67  % Time Elapsed:  1182.32 s
Iteration:  105 Progress:  87.50  % Time Elapsed:  1194.38 s
Iteration:  106 Progress:  88.33  % Time Elapsed:  1206.37 s
Iteration:  107 Progress:  89.17  % Time Elapsed:  1218.52 s
Iteration:  108 Progress:  90.00  % Time Elapsed:  1225.10 s
Epoch 17 Finished.  Time per Epoch:  68.06 s
Iteration:  109 Progress:  90.83  % Time Elapsed:  1238.11 s
Iteration:  110 Progress:  91.67  % Time Elapsed:  1251.16 s
Iteration:  111 Progress:  92.50  % Time Elapsed:  1265.03 s
Iteration:  112 Progress:  93.33  % Time Elapsed:  1277.35 s
Iteration:  113 Progress:  94.17  % Time Elapsed:  1289.44 s
Iteration:  114 Progress:  95.00  % Time Elapsed:  1296.16 s
Epoch 18 Finished.  Time per Epoch:  68.22 s
Iteration:  115 Progress:  95.83  % Time Elapsed:  1308.04 s
Iteration:  116 Progress:  96.67  % Time Elapsed:  1320.39 s
Iteration:  117 Progress:  97.50  % Time Elapsed:  1333.39 s
Iteration:  118 Progress:  98.33  % Time Elapsed:  1345.60 s
Iteration:  119 Progress:  99.17  % Time Elapsed:  1357.61 s
Iteration:  120 Progress:  100.00  % Time Elapsed:  1364.23 s
Epoch 19 Finished.  Time per Epoch:  68.21 s
```






```
Final Training Accuracy: 0.9969947407963937
Final Validation Accuracy: 0.5417607223476298
Total time:   1364.24 s  Time per Epoch:  68.21 s
```

In [ ]:

```
class Gesture_CNN_new(nn.Module):
  def __init__(self):
      super(Gesture_CNN_new,self).__init__()
      self.name = "Gesture"
      self.conv1 = nn.Conv2d(3, 5, 5) #RGB 3 Channels , 5x5 kernel size
      self.pool = nn.MaxPool2d(2, 2) #2x2 max pooling
      self.conv2 = nn.Conv2d(5, 10, 5) #conv layer 10filter 5x5
      self.conv3 = nn.Conv2d(10, 15, 5) #conv layer 15filter 5x5
      self.fc1 = nn.Linear(15 * 24 * 24, 32)
      self.fc2 = nn.Linear(32, 16)
      self.fc3 = nn.Linear(16, 9)

  def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = self.pool(F.relu(self.conv2(x)))
        x = self.pool(F.relu(self.conv3(x)))
        x = x.view(-1, 15 * 24 * 24)
        x = F.relu(self.fc1(x))
        x = F.relu(self.fc2(x))
        x = self.fc3(x)
        x = x.squeeze(1) # Flatten to [batch_size]
        return x

use_cuda = True
model = Gesture_CNN_new()
```

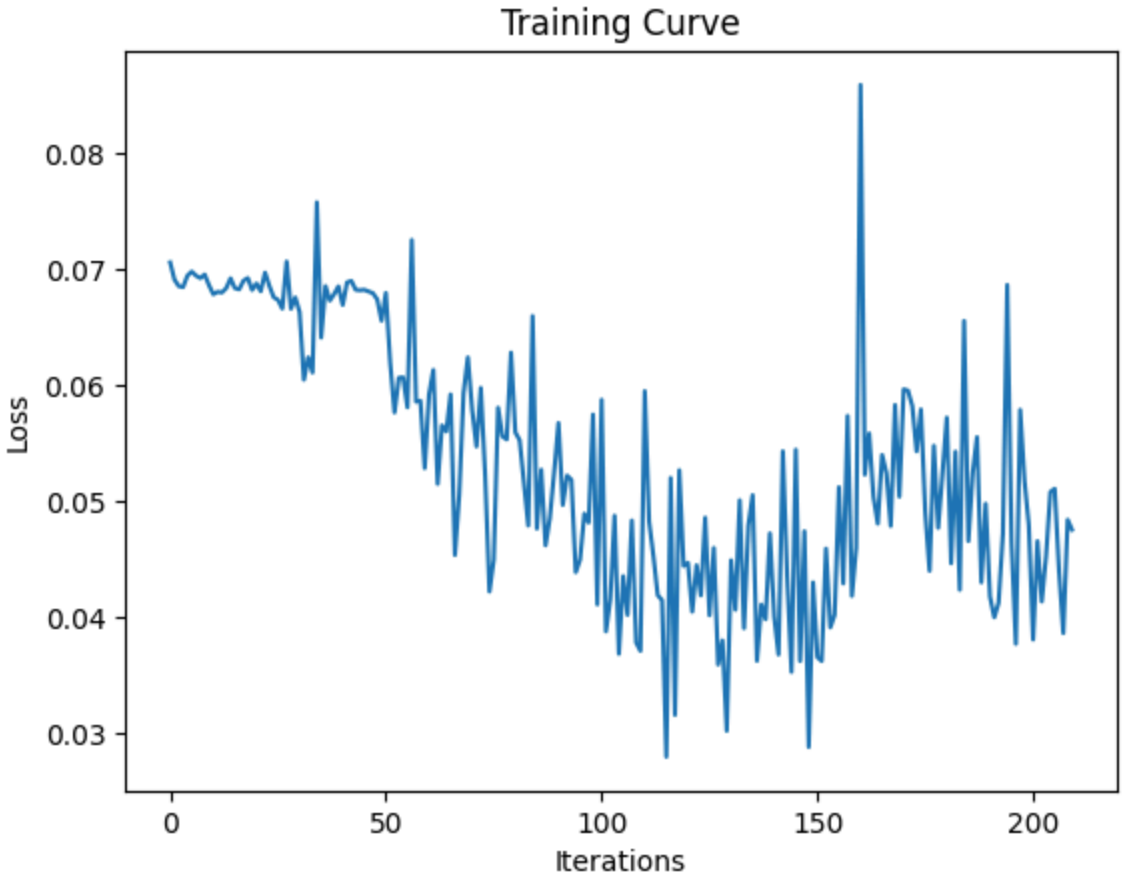
```
if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')

train(model,train_dataset,batch_size=32, num_epochs=5, lr=0.04)
```

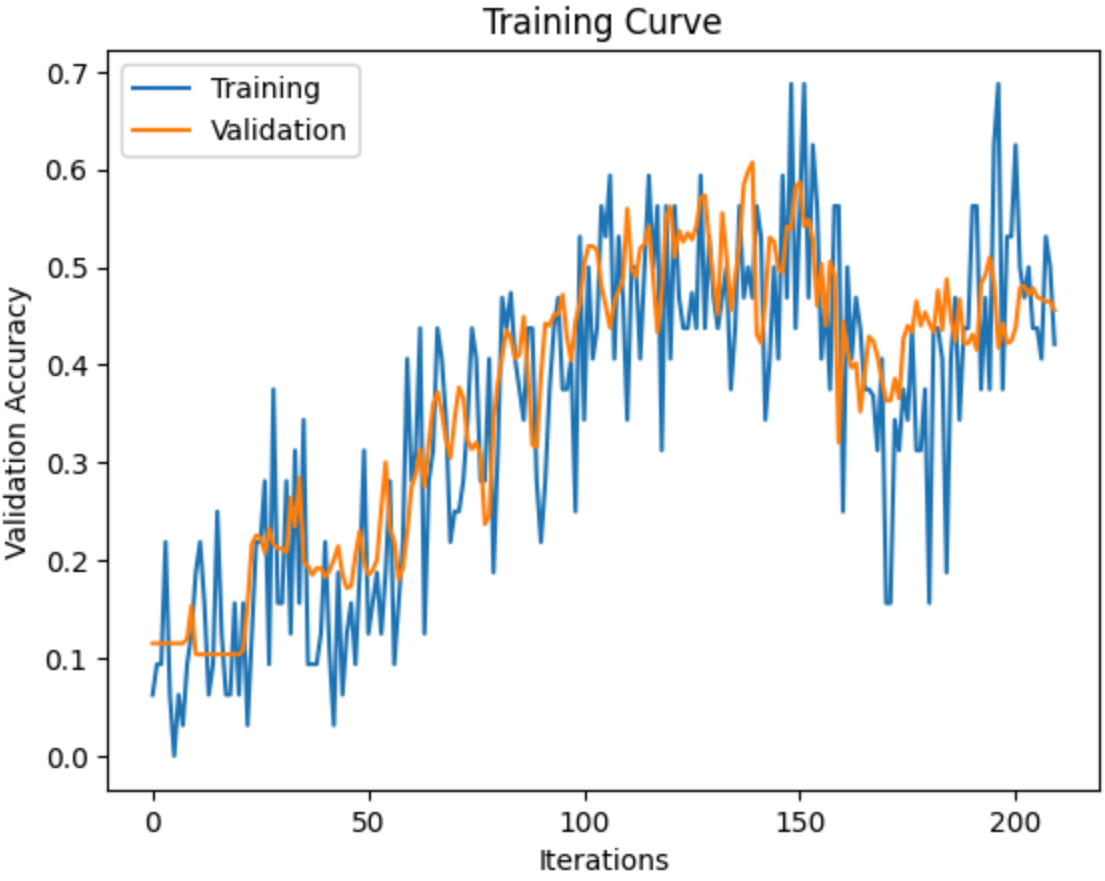
```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.48  % Time Elapsed:   6.19 s
Iteration:  2 Progress:   0.95  % Time Elapsed:  11.50 s
Iteration:  3 Progress:   1.43  % Time Elapsed:  17.60 s
Iteration:  4 Progress:   1.90  % Time Elapsed:  23.00 s
Iteration:  5 Progress:   2.38  % Time Elapsed:  28.68 s
Iteration:  6 Progress:   2.86  % Time Elapsed:  34.73 s
Iteration:  7 Progress:   3.33  % Time Elapsed:  40.13 s
Iteration:  8 Progress:   3.81  % Time Elapsed:  46.32 s
Iteration:  9 Progress:   4.29  % Time Elapsed:  51.59 s
Iteration:  10 Progress:   4.76  % Time Elapsed:  57.28 s
Iteration:  11 Progress:   5.24  % Time Elapsed:  63.04 s
Iteration:  12 Progress:   5.71  % Time Elapsed:  68.36 s
Iteration:  13 Progress:   6.19  % Time Elapsed:  74.45 s
Iteration:  14 Progress:   6.67  % Time Elapsed:  79.77 s
Iteration:  15 Progress:   7.14  % Time Elapsed:  85.67 s
Iteration:  16 Progress:   7.62  % Time Elapsed:  91.40 s
Iteration:  17 Progress:   8.10  % Time Elapsed:  96.65 s
Iteration:  18 Progress:   8.57  % Time Elapsed:  102.87 s
Iteration:  19 Progress:   9.05  % Time Elapsed:  108.17 s
Iteration:  20 Progress:   9.52  % Time Elapsed:  114.26 s
Iteration:  21 Progress:  10.00  % Time Elapsed:  119.66 s
Iteration:  22 Progress:  10.48  % Time Elapsed:  125.29 s
Iteration:  23 Progress:  10.95  % Time Elapsed:  131.54 s
Iteration:  24 Progress:  11.43  % Time Elapsed:  137.13 s
Iteration:  25 Progress:  11.90  % Time Elapsed:  143.58 s
Iteration:  26 Progress:  12.38  % Time Elapsed:  148.99 s
Iteration:  27 Progress:  12.86  % Time Elapsed:  154.88 s
Iteration:  28 Progress:  13.33  % Time Elapsed:  160.49 s
Iteration:  29 Progress:  13.81  % Time Elapsed:  165.66 s
Iteration:  30 Progress:  14.29  % Time Elapsed:  171.71 s
Iteration:  31 Progress:  14.76  % Time Elapsed:  176.91 s
Iteration:  32 Progress:  15.24  % Time Elapsed:  182.79 s
Iteration:  33 Progress:  15.71  % Time Elapsed:  188.28 s
Iteration:  34 Progress:  16.19  % Time Elapsed:  193.59 s
Iteration:  35 Progress:  16.67  % Time Elapsed:  199.73 s
Iteration:  36 Progress:  17.14  % Time Elapsed:  204.91 s
Iteration:  37 Progress:  17.62  % Time Elapsed:  210.92 s
Iteration:  38 Progress:  18.10  % Time Elapsed:  216.20 s
Iteration:  39 Progress:  18.57  % Time Elapsed:  221.51 s
Iteration:  40 Progress:  19.05  % Time Elapsed:  227.72 s
Iteration:  41 Progress:  19.52  % Time Elapsed:  232.91 s
Iteration:  42 Progress:  20.00  % Time Elapsed:  238.73 s
Epoch 0 Finished.  Time per Epoch:  238.73 s
Iteration:  43 Progress:  20.48  % Time Elapsed:  243.89 s
Iteration:  44 Progress:  20.95  % Time Elapsed:  249.28 s
Iteration:  45 Progress:  21.43  % Time Elapsed:  255.33 s
Iteration:  46 Progress:  21.90  % Time Elapsed:  260.58 s
Iteration:  47 Progress:  22.38  % Time Elapsed:  266.69 s
Iteration:  48 Progress:  22.86  % Time Elapsed:  271.93 s
Iteration:  49 Progress:  23.33  % Time Elapsed:  277.29 s
Iteration:  50 Progress:  23.81  % Time Elapsed:  283.18 s
Iteration:  51 Progress:  24.29  % Time Elapsed:  288.33 s
Iteration:  52 Progress:  24.76  % Time Elapsed:  294.44 s
Iteration:  53 Progress:  25.24  % Time Elapsed:  299.74 s
Iteration:  54 Progress:  25.71  % Time Elapsed:  305.35 s
```

```
Iteration:  55 Progress:  26.19  % Time Elapsed:  311.30 s
Iteration:  56 Progress:  26.67  % Time Elapsed:  316.60 s
Iteration:  57 Progress:  27.14  % Time Elapsed:  322.75 s
Iteration:  58 Progress:  27.62  % Time Elapsed:  328.11 s
Iteration:  59 Progress:  28.10  % Time Elapsed:  333.96 s
Iteration:  60 Progress:  28.57  % Time Elapsed:  339.50 s
Iteration:  61 Progress:  29.05  % Time Elapsed:  344.70 s
Iteration:  62 Progress:  29.52  % Time Elapsed:  350.71 s
Iteration:  63 Progress:  30.00  % Time Elapsed:  355.94 s
Iteration:  64 Progress:  30.48  % Time Elapsed:  361.75 s
Iteration:  65 Progress:  30.95  % Time Elapsed:  367.50 s
Iteration:  66 Progress:  31.43  % Time Elapsed:  372.72 s
Iteration:  67 Progress:  31.90  % Time Elapsed:  379.02 s
Iteration:  68 Progress:  32.38  % Time Elapsed:  384.43 s
Iteration:  69 Progress:  32.86  % Time Elapsed:  390.65 s
Iteration:  70 Progress:  33.33  % Time Elapsed:  395.96 s
Iteration:  71 Progress:  33.81  % Time Elapsed:  401.45 s
Iteration:  72 Progress:  34.29  % Time Elapsed:  407.52 s
Iteration:  73 Progress:  34.76  % Time Elapsed:  412.87 s
Iteration:  74 Progress:  35.24  % Time Elapsed:  419.17 s
Iteration:  75 Progress:  35.71  % Time Elapsed:  424.51 s
Iteration:  76 Progress:  36.19  % Time Elapsed:  430.29 s
Iteration:  77 Progress:  36.67  % Time Elapsed:  435.97 s
Iteration:  78 Progress:  37.14  % Time Elapsed:  441.24 s
Iteration:  79 Progress:  37.62  % Time Elapsed:  447.33 s
Iteration:  80 Progress:  38.10  % Time Elapsed:  452.60 s
Iteration:  81 Progress:  38.57  % Time Elapsed:  458.64 s
Iteration:  82 Progress:  39.05  % Time Elapsed:  464.13 s
Iteration:  83 Progress:  39.52  % Time Elapsed:  469.43 s
Iteration:  84 Progress:  40.00  % Time Elapsed:  475.47 s
Epoch 1 Finished.  Time per Epoch:  237.74 s
Iteration:  85 Progress:  40.48  % Time Elapsed:  480.86 s
Iteration:  86 Progress:  40.95  % Time Elapsed:  487.14 s
Iteration:  87 Progress:  41.43  % Time Elapsed:  492.52 s
Iteration:  88 Progress:  41.90  % Time Elapsed:  498.05 s
Iteration:  89 Progress:  42.38  % Time Elapsed:  504.32 s
Iteration:  90 Progress:  42.86  % Time Elapsed:  509.59 s
Iteration:  91 Progress:  43.33  % Time Elapsed:  515.79 s
Iteration:  92 Progress:  43.81  % Time Elapsed:  521.11 s
Iteration:  93 Progress:  44.29  % Time Elapsed:  526.95 s
Iteration:  94 Progress:  44.76  % Time Elapsed:  532.67 s
Iteration:  95 Progress:  45.24  % Time Elapsed:  538.03 s
Iteration:  96 Progress:  45.71  % Time Elapsed:  544.27 s
Iteration:  97 Progress:  46.19  % Time Elapsed:  549.69 s
Iteration:  98 Progress:  46.67  % Time Elapsed:  555.91 s
Iteration:  99 Progress:  47.14  % Time Elapsed:  561.32 s
Iteration:  100 Progress:  47.62  % Time Elapsed:  566.78 s
Iteration:  101 Progress:  48.10  % Time Elapsed:  572.80 s
Iteration:  102 Progress:  48.57  % Time Elapsed:  578.06 s
Iteration:  103 Progress:  49.05  % Time Elapsed:  584.22 s
Iteration:  104 Progress:  49.52  % Time Elapsed:  589.50 s
Iteration:  105 Progress:  50.00  % Time Elapsed:  595.15 s
Iteration:  106 Progress:  50.48  % Time Elapsed:  600.92 s
Iteration:  107 Progress:  50.95  % Time Elapsed:  606.15 s
Iteration:  108 Progress:  51.43  % Time Elapsed:  612.32 s
Iteration:  109 Progress:  51.90  % Time Elapsed:  617.52 s
```

```
Iteration:  110 Progress:  52.38  % Time Elapsed:  623.18 s
Iteration:  111 Progress:  52.86  % Time Elapsed:  628.93 s
Iteration:  112 Progress:  53.33  % Time Elapsed:  634.18 s
Iteration:  113 Progress:  53.81  % Time Elapsed:  640.46 s
Iteration:  114 Progress:  54.29  % Time Elapsed:  645.78 s
Iteration:  115 Progress:  54.76  % Time Elapsed:  651.65 s
Iteration:  116 Progress:  55.24  % Time Elapsed:  657.22 s
Iteration:  117 Progress:  55.71  % Time Elapsed:  662.45 s
Iteration:  118 Progress:  56.19  % Time Elapsed:  668.61 s
Iteration:  119 Progress:  56.67  % Time Elapsed:  673.89 s
Iteration:  120 Progress:  57.14  % Time Elapsed:  679.94 s
Iteration:  121 Progress:  57.62  % Time Elapsed:  685.28 s
Iteration:  122 Progress:  58.10  % Time Elapsed:  690.48 s
Iteration:  123 Progress:  58.57  % Time Elapsed:  696.63 s
Iteration:  124 Progress:  59.05  % Time Elapsed:  701.79 s
Iteration:  125 Progress:  59.52  % Time Elapsed:  707.77 s
Iteration:  126 Progress:  60.00  % Time Elapsed:  712.88 s
Epoch 2 Finished.  Time per Epoch:  237.63 s
Iteration:  127 Progress:  60.48  % Time Elapsed:  718.08 s
Iteration:  128 Progress:  60.95  % Time Elapsed:  724.23 s
Iteration:  129 Progress:  61.43  % Time Elapsed:  729.40 s
Iteration:  130 Progress:  61.90  % Time Elapsed:  735.42 s
Iteration:  131 Progress:  62.38  % Time Elapsed:  740.63 s
Iteration:  132 Progress:  62.86  % Time Elapsed:  745.92 s
Iteration:  133 Progress:  63.33  % Time Elapsed:  752.00 s
Iteration:  134 Progress:  63.81  % Time Elapsed:  757.30 s
Iteration:  135 Progress:  64.29  % Time Elapsed:  763.40 s
Iteration:  136 Progress:  64.76  % Time Elapsed:  768.69 s
Iteration:  137 Progress:  65.24  % Time Elapsed:  774.43 s
Iteration:  138 Progress:  65.71  % Time Elapsed:  780.33 s
Iteration:  139 Progress:  66.19  % Time Elapsed:  785.53 s
Iteration:  140 Progress:  66.67  % Time Elapsed:  791.65 s
Iteration:  141 Progress:  67.14  % Time Elapsed:  796.82 s
Iteration:  142 Progress:  67.62  % Time Elapsed:  802.38 s
Iteration:  143 Progress:  68.10  % Time Elapsed:  808.13 s
Iteration:  144 Progress:  68.57  % Time Elapsed:  813.32 s
Iteration:  145 Progress:  69.05  % Time Elapsed:  819.33 s
Iteration:  146 Progress:  69.52  % Time Elapsed:  824.57 s
Iteration:  147 Progress:  70.00  % Time Elapsed:  830.16 s
Iteration:  148 Progress:  70.48  % Time Elapsed:  835.91 s
Iteration:  149 Progress:  70.95  % Time Elapsed:  841.17 s
Iteration:  150 Progress:  71.43  % Time Elapsed:  847.27 s
Iteration:  151 Progress:  71.90  % Time Elapsed:  852.54 s
Iteration:  152 Progress:  72.38  % Time Elapsed:  859.07 s
Iteration:  153 Progress:  72.86  % Time Elapsed:  864.65 s
Iteration:  154 Progress:  73.33  % Time Elapsed:  869.78 s
Iteration:  155 Progress:  73.81  % Time Elapsed:  875.85 s
Iteration:  156 Progress:  74.29  % Time Elapsed:  880.97 s
Iteration:  157 Progress:  74.76  % Time Elapsed:  886.64 s
Iteration:  158 Progress:  75.24  % Time Elapsed:  892.34 s
Iteration:  159 Progress:  75.71  % Time Elapsed:  897.59 s
Iteration:  160 Progress:  76.19  % Time Elapsed:  903.61 s
Iteration:  161 Progress:  76.67  % Time Elapsed:  908.88 s
Iteration:  162 Progress:  77.14  % Time Elapsed:  914.79 s
Iteration:  163 Progress:  77.62  % Time Elapsed:  920.33 s
Iteration:  164 Progress:  78.10  % Time Elapsed:  925.50 s
```

```
Iteration:  165 Progress:  78.57  % Time Elapsed:  931.52 s
Iteration:  166 Progress:  79.05  % Time Elapsed:  936.66 s
Iteration:  167 Progress:  79.52  % Time Elapsed:  942.53 s
Iteration:  168 Progress:  80.00  % Time Elapsed:  947.83 s
Epoch 3 Finished.  Time per Epoch:  236.96 s
Iteration:  169 Progress:  80.48  % Time Elapsed:  953.11 s
Iteration:  170 Progress:  80.95  % Time Elapsed:  959.24 s
Iteration:  171 Progress:  81.43  % Time Elapsed:  964.40 s
Iteration:  172 Progress:  81.90  % Time Elapsed:  970.19 s
Iteration:  173 Progress:  82.38  % Time Elapsed:  975.59 s
Iteration:  174 Progress:  82.86  % Time Elapsed:  980.70 s
Iteration:  175 Progress:  83.33  % Time Elapsed:  986.71 s
Iteration:  176 Progress:  83.81  % Time Elapsed:  991.89 s
Iteration:  177 Progress:  84.29  % Time Elapsed:  997.60 s
Iteration:  178 Progress:  84.76  % Time Elapsed:  1003.07 s
Iteration:  179 Progress:  85.24  % Time Elapsed:  1008.22 s
Iteration:  180 Progress:  85.71  % Time Elapsed:  1014.20 s
Iteration:  181 Progress:  86.19  % Time Elapsed:  1019.30 s
Iteration:  182 Progress:  86.67  % Time Elapsed:  1025.05 s
Iteration:  183 Progress:  87.14  % Time Elapsed:  1030.51 s
Iteration:  184 Progress:  87.62  % Time Elapsed:  1035.71 s
Iteration:  185 Progress:  88.10  % Time Elapsed:  1041.80 s
Iteration:  186 Progress:  88.57  % Time Elapsed:  1047.08 s
Iteration:  187 Progress:  89.05  % Time Elapsed:  1052.83 s
Iteration:  188 Progress:  89.52  % Time Elapsed:  1058.29 s
Iteration:  189 Progress:  90.00  % Time Elapsed:  1063.41 s
Iteration:  190 Progress:  90.48  % Time Elapsed:  1069.49 s
Iteration:  191 Progress:  90.95  % Time Elapsed:  1074.54 s
Iteration:  192 Progress:  91.43  % Time Elapsed:  1080.19 s
Iteration:  193 Progress:  91.90  % Time Elapsed:  1085.67 s
Iteration:  194 Progress:  92.38  % Time Elapsed:  1090.77 s
Iteration:  195 Progress:  92.86  % Time Elapsed:  1096.84 s
Iteration:  196 Progress:  93.33  % Time Elapsed:  1102.15 s
Iteration:  197 Progress:  93.81  % Time Elapsed:  1107.96 s
Iteration:  198 Progress:  94.29  % Time Elapsed:  1113.44 s
Iteration:  199 Progress:  94.76  % Time Elapsed:  1118.60 s
Iteration:  200 Progress:  95.24  % Time Elapsed:  1124.69 s
Iteration:  201 Progress:  95.71  % Time Elapsed:  1129.86 s
Iteration:  202 Progress:  96.19  % Time Elapsed:  1135.65 s
Iteration:  203 Progress:  96.67  % Time Elapsed:  1141.16 s
Iteration:  204 Progress:  97.14  % Time Elapsed:  1146.56 s
Iteration:  205 Progress:  97.62  % Time Elapsed:  1152.58 s
Iteration:  206 Progress:  98.10  % Time Elapsed:  1157.67 s
Iteration:  207 Progress:  98.57  % Time Elapsed:  1163.40 s
Iteration:  208 Progress:  99.05  % Time Elapsed:  1168.80 s
Iteration:  209 Progress:  99.52  % Time Elapsed:  1173.89 s
Iteration:  210 Progress:  100.00  % Time Elapsed:  1179.82 s
Epoch 4 Finished.  Time per Epoch:  235.96 s
```


Training Curve
Loss
Iterations
0.08
0.07
0.06
0.05
0.04
0.03
0
50
100
150
200


Training Curve
Training
Validation
Validation Accuracy
Iterations
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200

```
Final Training Accuracy: 0.48084147257700977
Final Validation Accuracy: 0.45598194130925507
Total time:   1179.82 s  Time per Epoch:  235.96 s
```

Part (c) - 3 pt

Choose the best model out of all the ones that you have trained. Justify your choice.

In [ ]:
```
#The best model performance I got was from the first model,
#with these hyperparameters:
#batch_size=64, #num_epochs=20, lr=0.02, 2 CNN layers

#best results I obtained:
#Final Training Accuracy: 0.9691960931630353 (96.9%)
#Final Validation Accuracy: 0.7358916478555305 (73.6%)

#Although the other model has higher training accuracy however, performance
#on the validation accuracy is more important
#Final Training Accuracy: 0.9969947407963937 (99.7%)
#Final Validation Accuracy: 0.5417607223476298
```

Part (d) - 4 pt

Report the test accuracy of your best model. You should only do this step once and prior to this step you should have only used the training and validation data.

In [ ]:
```
final_model = Gesture_CNN()
test_loader = torch.utils.data.DataLoader(test_dataset, batch_size=64, shuffle=True
final_model.load_state_dict(torch.load('Gesture_bs64_lr0.02_epoch20'))
correct = 0
total = 0
batch_size = 64
use_cuda = True
if use_cuda and torch.cuda.is_available():
  final_model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')
for imgs, labels in torch.utils.data.DataLoader(test_dataset, batch_size=batch_size
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
           imgs = imgs.cuda()
           labels = labels.cuda()
        output = final_model(imgs)

        #select index with maximum prediction score
        pred = output.max(1, keepdim=True)[1]
        correct += pred.eq(labels.view_as(pred)).sum().item()
        total += imgs.shape[0]
print("Test Accuracy: ",correct/total)
```

```
CUDA is not available.  Training on CPU ...
Test Accuracy:  0.8539325842696629
```

Test Accuracy: 0.8539 (85.4%)

4. Transfer Learning [15 pt]

For many image classification tasks, it is generally not a good idea to train a very large deep neural network model from scratch due to the enormous compute requirements and lack of sufficient amounts of training data.

One of the better options is to try using an existing model that performs a similar task to the one you need to solve. This method of utilizing a pre-trained network for other similar tasks is broadly termed **Transfer Learning**. In this assignment, we will use Transfer Learning to extract features from the hand gesture images. Then, train a smaller network to use these features as input and classify the hand gestures.

As you have learned from the CNN lecture, convolution layers extract various features from the images which get utilized by the fully connected layers for correct classification. AlexNet architecture played a pivotal role in establishing Deep Neural Nets as a go-to tool for image classification problems and we will use an ImageNet pre-trained AlexNet model to extract features in this assignment.

Part (a) - 5 pt

Here is the code to load the AlexNet network, with pretrained weights. When you first run the code, PyTorch will download the pretrained weights from the internet.

In [3]:
```
import torchvision.models
alexnet = torchvision.models.alexnet(pretrained=True)
```

```
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:208: UserWarnin
g: The parameter 'pretrained' is deprecated since 0.13 and may be removed in the fut
ure, please use 'weights' instead.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:223: UserWarnin
g: Arguments other than a weight enum or `None` for 'weights' are deprecated since
0.13 and may be removed in the future. The current behavior is equivalent to passing
`weights=AlexNet_Weights.IMAGENET1K_V1`. You can also use `weights=AlexNet_Weights.D
EFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
Downloading: "https://download.pytorch.org/models/alexnet-owt-7be5be79.pth" to /roo
t/.cache/torch/hub/checkpoints/alexnet-owt-7be5be79.pth
100%|██████████| 233M/233M [00:02<00:00, 91.3MB/s]
```

The alexnet model is split up into two components: *alexnet.features* and *alexnet.classifier*. The first neural network component, *alexnet.features*, is used to compute convolutional features, which are taken as input in *alexnet.classifier*.

The neural network alexnet.features expects an image tensor of shape Nx3x224x224 as input and it will output a tensor of shape Nx256x6x6 . (N = batch size).

Compute the AlexNet features for each of your training, validation, and test data. Here is an example code snippet showing how you can compute the AlexNet features for some images (your actual code might be different):

In [ ]:
```
# img = ... a PyTorch tensor with shape [N,3,224,224] containing hand images ...
#features = alexnet.features(images)
```

Save the computed features. You will be using these features as input to your neural network in Part (b), and you do not want to re-compute the features every time. Instead, run *alexnet.features* once for each image, and save the result.

In [39]:
```
path = '/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures'
os.makedirs(path, exist_ok=True)
path = '/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/train'
os.makedirs(path, exist_ok=True)
path = '/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/val'
os.makedirs(path, exist_ok=True)
path = '/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/test'
os.makedirs(path, exist_ok=True)
```

In [40]:
```
  # img = ... a PyTorch tensor with shape [N,3,224,224] containing hand images ...
  # define dataloader parameters
classes = ['A','B','C','D','E','F','G','H','I']

for subdir in classes:
      path = f'/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/train/{s
      os.makedirs(path, exist_ok=True)
      path = f'/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/val/{sub
      os.makedirs(path, exist_ok=True)
      path = f'/content/gdrive/MyDrive/ColabNotebooks/Lab3_AlexNetFeatures/test/{su
      os.makedirs(path, exist_ok=True)


i = 0
  # img = ... a PyTorch tensor with shape [N,3,224,224] containing hand images ...
  # define dataloader parameters
batch_size  = 1 #with batchsize >1 was not wrking would need like anther loopp
num_workers =0
train_loader = torch.utils.data.DataLoader(train_dataset, batch_size=batch_size,
                                           num_workers=num_workers, shuffle=True)
val_loader = torch.utils.data.DataLoader(val_dataset, batch_size=batch_size,
                                           num_workers=num_workers, shuffle=True)
test_loader = torch.utils.data.DataLoader(test_dataset, batch_size=batch_size,
                                           num_workers=num_workers, shuffle=True)
  # obtain one batch of training images
  #dataiter = iter(train_loader)
  #images, labels = next(dataiter)
  #images = images.numpy() # convert images to numpy for display
alex_train , alex_val, alex_test = [],[],[]

i = 0
for imgs,labels in train_loader:
        features = alexnet.features(imgs)
```

```
        class_label = classes[labels.item()]
        torch.save(features.squeeze(0).detach(), f'/content/gdrive/MyDrive/ColabNot
        #alex_train.append(features.detach().numpy())
        i += 1

i1 = 0
for imgs,labels in val_loader:
      features = alexnet.features(imgs)
      class_label = classes[labels.item()]
      torch.save(features.squeeze(0).detach(), f'/content/gdrive/MyDrive/ColabNoteb
      i1 += 1

i2 = 0
for imgs,labels in test_loader:
      features = alexnet.features(imgs)
      class_label = classes[labels.item()]
      torch.save(features.squeeze(0).detach(),f'/content/gdrive/MyDrive/ColabNotebo
      i2 += 1
```

Part (b) - 3 pt

Build a convolutional neural network model that takes as input these AlexNet features, and makes a prediction. Your model should be a subclass of nn.Module.

Explain your choice of neural network architecture: how many layers did you choose? What types of layers did you use: fully-connected or convolutional? What about other decisions like pooling layers, activation functions, number of channels / hidden units in each layer?

Here is an example of how your model may be called:

In [ ]:
```
# features = ... load precomputed alexnet.features(img) ...
#output = model(features)
#prob = F.softmax(output)
```

In [57]:
```
class Gesture_Alex(nn.Module):
  def __init__(self):
      super(Gesture_Alex,self).__init__()
      self.name = "Gesture_Alex"
      self.fc1 = nn.Linear(256 * 6 * 6, 32) #Nx256x6x6
      self.fc2 = nn.Linear(32, 9)

  def forward(self, x):
        x = x.view(-1, 256 * 6 * 6) #flatten
        x = F.relu(self.fc1(x))
        x = self.fc2(x)
        return x
```

The Gesture Alex Architecture i choose is fully connected neural network arch(ANN), 2 linear layers, alexNet has CNN features already.No pooling layer.Layer1 used activation function ReLU, and output of layer 2 is 9 gesture classes.

Part (c) - 5 pt

Train your new network, including any hyperparameter tuning. Plot and submit the training curve of your best model only.

Note: Depending on how you are caching (saving) your AlexNet features, PyTorch might still be tracking updates to the **AlexNet weights**, which we are not tuning. One workaround is to convert your AlexNet feature tensor into a numpy array, and then back into a PyTorch tensor.

In [ ]:
```
#tensor = torch.from_numpy(tensor.detach().numpy())
```

In [55]:
```
def train(model,train_loader,val_loader, batch_size , num_epochs,lr):
    #train_loader = torch.utils.data.DataLoader(data, batch_size=batch_size)
    # train_loader = torch.utils.data.DataLoader(train_data, batch_size=batch_size,
                                          #num_workers=num_workers, shuffle=True)
    criterion = nn.CrossEntropyLoss()
    optimizer = optim.SGD(model.parameters(), lr, momentum=0.9)

    iters, losses, train_acc, val_acc = [], [], [], []

    # training
    n = 0 # the number of iterations
    start_time=time.time()
    for epoch in range(num_epochs):
        mini_b=0
        mini_batch_correct = 0
        Mini_batch_total = 0
        for imgs, labels in iter(train_loader):


            ##############################################
            #To Enable GPU Usage
            if use_cuda and torch.cuda.is_available():
              imgs = imgs.cuda()
              labels = labels.cuda()
            ##############################################


            out = model(imgs)             # forward pass
            loss = criterion(out, labels) # compute the total loss
            loss.backward()               # backward pass (compute parameter update
            optimizer.step()              # make the updates for each parameter
            optimizer.zero_grad()         # a clean up step for PyTorch
                  # save the current training information



            ##### Mini_batch Accuracy ##### We don't compute accuracy on the whole
            pred = out.max(1, keepdim=True)[1]
            mini_batch_correct = pred.eq(labels.view_as(pred)).sum().item()
            Mini_batch_total = imgs.shape[0]
            # Append mini-batch accuracy for the training curve
            train_acc.append((mini_batch_correct / Mini_batch_total))
```

```
            ############################

          # save the current training information
            iters.append(n)
            losses.append(float(loss)/batch_size)             # compute *average* l
            val_acc.append(get_accuracy(model, val_loader))  # compute validation a
            n += 1
            mini_b += 1
            print("Iteration: ",n,'Progress: % 6.2f ' % ((epoch * len(train_loader)


        print ("Epoch %d Finished. " % epoch ,"Time per Epoch: % 6.2f s "% ((time.t


    end_time= time.time()
    # plotting
    plt.title("Training Curve")
    plt.plot(iters, losses, label="Train")
    plt.xlabel("Iterations")
    plt.ylabel("Loss")
    plt.show()

    plt.title("Training Curve")
    plt.plot(iters, train_acc, label="Training")
    plt.plot(iters, val_acc, label="Validation")
    plt.xlabel("Iterations")
    plt.ylabel("Validation Accuracy")
    plt.legend(loc='best')
    plt.show()

    train_acc.append(get_accuracy(model, train_loader))
    val_acc.append(get_accuracy(model, val_loader))
    print("Final Training Accuracy: {}".format(train_acc[-1]))
    print("Final Validation Accuracy: {}".format(val_acc[-1]))
    print ("Total time:  % 6.2f s  Time per Epoch: % 6.2f s " % ( (end_time-start_t
    torch.save(model.state_dict(), f'{model.name}_bs{batch_size}_lr{lr}_epoch{num_e
```

In [53]:

```
def get_accuracy(model,data_loader ):


    correct = 0
    total = 0
    for imgs, labels in data_loader:
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
           imgs = imgs.cuda()
           labels = labels.cuda()
        output = model(imgs)

        #select index with maximum prediction score
        pred = output.max(1, keepdim=True)[1]
        correct += pred.eq(labels.view_as(pred)).sum().item()
        total += imgs.shape[0]
    return correct / total
```

In [56]:

```
use_cuda = True
model = Gesture_Alex()
train_feature_dataset = datasets.DatasetFolder( '/content/gdrive/MyDrive/ColabNoteb
val_feature_dataset = datasets.DatasetFolder('/content/gdrive/MyDrive/ColabNotebook
test_features_dataset= datasets.DatasetFolder('/content/gdrive/MyDrive/ColabNoteboo

train_loader_feature = torch.utils.data.DataLoader(train_feature_dataset, batch_siz
val_loader_feature = torch.utils.data.DataLoader(val_feature_dataset, batch_size=64
test_loader_feature = torch.utils.data.DataLoader(test_features_dataset, batch_size
if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')

train(model,train_loader_feature,val_loader_feature,batch_size=64, num_epochs=20, l
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.12  % Time Elapsed:   2.20 s
Iteration:  2 Progress:   0.25  % Time Elapsed:   4.27 s
Iteration:  3 Progress:   0.38  % Time Elapsed:   6.51 s
Iteration:  4 Progress:   0.50  % Time Elapsed:   8.77 s
Iteration:  5 Progress:   0.62  % Time Elapsed:  10.84 s
Iteration:  6 Progress:   0.75  % Time Elapsed:  13.09 s
Iteration:  7 Progress:   0.88  % Time Elapsed:  15.46 s
Iteration:  8 Progress:   1.00  % Time Elapsed:  17.77 s
Iteration:  9 Progress:   1.12  % Time Elapsed:  20.00 s
Iteration:  10 Progress:   1.25  % Time Elapsed:  22.03 s
Iteration:  11 Progress:   1.38  % Time Elapsed:  24.38 s
Iteration:  12 Progress:   1.50  % Time Elapsed:  26.53 s
Iteration:  13 Progress:   1.62  % Time Elapsed:  28.79 s
Iteration:  14 Progress:   1.75  % Time Elapsed:  31.19 s
Iteration:  15 Progress:   1.88  % Time Elapsed:  33.47 s
Iteration:  16 Progress:   2.00  % Time Elapsed:  35.64 s
Iteration:  17 Progress:   2.12  % Time Elapsed:  37.71 s
Iteration:  18 Progress:   2.25  % Time Elapsed:  39.93 s
Iteration:  19 Progress:   2.38  % Time Elapsed:  41.99 s
Iteration:  20 Progress:   2.50  % Time Elapsed:  44.03 s
Iteration:  21 Progress:   2.62  % Time Elapsed:  46.25 s
Iteration:  22 Progress:   2.75  % Time Elapsed:  48.38 s
Iteration:  23 Progress:   2.88  % Time Elapsed:  50.52 s
Iteration:  24 Progress:   3.00  % Time Elapsed:  52.59 s
Iteration:  25 Progress:   3.12  % Time Elapsed:  55.07 s
Iteration:  26 Progress:   3.25  % Time Elapsed:  57.26 s
Iteration:  27 Progress:   3.38  % Time Elapsed:  59.50 s
Iteration:  28 Progress:   3.50  % Time Elapsed:  61.60 s
Iteration:  29 Progress:   3.62  % Time Elapsed:  64.30 s
Iteration:  30 Progress:   3.75  % Time Elapsed:  66.45 s
Iteration:  31 Progress:   3.88  % Time Elapsed:  68.72 s
Iteration:  32 Progress:   4.00  % Time Elapsed:  70.86 s
Iteration:  33 Progress:   4.12  % Time Elapsed:  73.19 s
Iteration:  34 Progress:   4.25  % Time Elapsed:  75.32 s
Iteration:  35 Progress:   4.38  % Time Elapsed:  77.32 s
Iteration:  36 Progress:   4.50  % Time Elapsed:  79.40 s
Iteration:  37 Progress:   4.62  % Time Elapsed:  81.46 s
Iteration:  38 Progress:   4.75  % Time Elapsed:  83.51 s
Iteration:  39 Progress:   4.88  % Time Elapsed:  85.79 s
Iteration:  40 Progress:   5.00  % Time Elapsed:  87.86 s
Epoch 0 Finished.  Time per Epoch:  87.86 s
Iteration:  41 Progress:   5.12  % Time Elapsed:  90.02 s
Iteration:  42 Progress:   5.25  % Time Elapsed:  92.08 s
Iteration:  43 Progress:   5.38  % Time Elapsed:  94.31 s
Iteration:  44 Progress:   5.50  % Time Elapsed:  96.37 s
Iteration:  45 Progress:   5.62  % Time Elapsed:  98.39 s
Iteration:  46 Progress:   5.75  % Time Elapsed:  100.48 s
Iteration:  47 Progress:   5.88  % Time Elapsed:  102.51 s
Iteration:  48 Progress:   6.00  % Time Elapsed:  104.49 s
Iteration:  49 Progress:   6.12  % Time Elapsed:  106.64 s
Iteration:  50 Progress:   6.25  % Time Elapsed:  108.80 s
Iteration:  51 Progress:   6.38  % Time Elapsed:  110.96 s
Iteration:  52 Progress:   6.50  % Time Elapsed:  112.99 s
Iteration:  53 Progress:   6.62  % Time Elapsed:  115.16 s
Iteration:  54 Progress:   6.75  % Time Elapsed:  117.14 s
```

```
Iteration:  55 Progress:   6.88  % Time Elapsed:  119.27 s
Iteration:  56 Progress:   7.00  % Time Elapsed:  121.38 s
Iteration:  57 Progress:   7.12  % Time Elapsed:  123.47 s
Iteration:  58 Progress:   7.25  % Time Elapsed:  125.59 s
Iteration:  59 Progress:   7.38  % Time Elapsed:  127.64 s
Iteration:  60 Progress:   7.50  % Time Elapsed:  129.72 s
Iteration:  61 Progress:   7.62  % Time Elapsed:  131.64 s
Iteration:  62 Progress:   7.75  % Time Elapsed:  133.73 s
Iteration:  63 Progress:   7.88  % Time Elapsed:  136.07 s
Iteration:  64 Progress:   8.00  % Time Elapsed:  138.69 s
Iteration:  65 Progress:   8.12  % Time Elapsed:  140.90 s
Iteration:  66 Progress:   8.25  % Time Elapsed:  142.83 s
Iteration:  67 Progress:   8.38  % Time Elapsed:  144.86 s
Iteration:  68 Progress:   8.50  % Time Elapsed:  146.83 s
Iteration:  69 Progress:   8.62  % Time Elapsed:  149.08 s
Iteration:  70 Progress:   8.75  % Time Elapsed:  151.11 s
Iteration:  71 Progress:   8.88  % Time Elapsed:  153.14 s
Iteration:  72 Progress:   9.00  % Time Elapsed:  155.19 s
Iteration:  73 Progress:   9.12  % Time Elapsed:  157.24 s
Iteration:  74 Progress:   9.25  % Time Elapsed:  159.24 s
Iteration:  75 Progress:   9.38  % Time Elapsed:  161.24 s
Iteration:  76 Progress:   9.50  % Time Elapsed:  163.23 s
Iteration:  77 Progress:   9.62  % Time Elapsed:  165.40 s
Iteration:  78 Progress:   9.75  % Time Elapsed:  167.46 s
Iteration:  79 Progress:   9.88  % Time Elapsed:  169.58 s
Iteration:  80 Progress:  10.00  % Time Elapsed:  171.45 s
Epoch 1 Finished.  Time per Epoch:  85.72 s
Iteration:  81 Progress:  10.12  % Time Elapsed:  173.41 s
Iteration:  82 Progress:  10.25  % Time Elapsed:  175.45 s
Iteration:  83 Progress:  10.38  % Time Elapsed:  177.40 s
Iteration:  84 Progress:  10.50  % Time Elapsed:  179.49 s
Iteration:  85 Progress:  10.62  % Time Elapsed:  181.52 s
Iteration:  86 Progress:  10.75  % Time Elapsed:  183.63 s
Iteration:  87 Progress:  10.88  % Time Elapsed:  185.77 s
Iteration:  88 Progress:  11.00  % Time Elapsed:  187.87 s
Iteration:  89 Progress:  11.12  % Time Elapsed:  190.08 s
Iteration:  90 Progress:  11.25  % Time Elapsed:  192.13 s
Iteration:  91 Progress:  11.38  % Time Elapsed:  194.11 s
Iteration:  92 Progress:  11.50  % Time Elapsed:  196.15 s
Iteration:  93 Progress:  11.62  % Time Elapsed:  198.20 s
Iteration:  94 Progress:  11.75  % Time Elapsed:  200.38 s
Iteration:  95 Progress:  11.88  % Time Elapsed:  202.40 s
Iteration:  96 Progress:  12.00  % Time Elapsed:  204.52 s
Iteration:  97 Progress:  12.12  % Time Elapsed:  206.50 s
Iteration:  98 Progress:  12.25  % Time Elapsed:  208.51 s
Iteration:  99 Progress:  12.38  % Time Elapsed:  210.56 s
Iteration:  100 Progress:  12.50  % Time Elapsed:  212.64 s
Iteration:  101 Progress:  12.62  % Time Elapsed:  214.85 s
Iteration:  102 Progress:  12.75  % Time Elapsed:  217.04 s
Iteration:  103 Progress:  12.88  % Time Elapsed:  219.48 s
Iteration:  104 Progress:  13.00  % Time Elapsed:  221.60 s
Iteration:  105 Progress:  13.12  % Time Elapsed:  223.63 s
Iteration:  106 Progress:  13.25  % Time Elapsed:  225.79 s
Iteration:  107 Progress:  13.38  % Time Elapsed:  227.73 s
Iteration:  108 Progress:  13.50  % Time Elapsed:  229.71 s
Iteration:  109 Progress:  13.63  % Time Elapsed:  231.76 s
```

```
Iteration:  110 Progress:  13.75  % Time Elapsed:  233.88 s
Iteration:  111 Progress:  13.88  % Time Elapsed:  235.97 s
Iteration:  112 Progress:  14.00  % Time Elapsed:  238.03 s
Iteration:  113 Progress:  14.12  % Time Elapsed:  240.12 s
Iteration:  114 Progress:  14.25  % Time Elapsed:  242.15 s
Iteration:  115 Progress:  14.37  % Time Elapsed:  244.17 s
Iteration:  116 Progress:  14.50  % Time Elapsed:  246.29 s
Iteration:  117 Progress:  14.62  % Time Elapsed:  248.42 s
Iteration:  118 Progress:  14.75  % Time Elapsed:  250.48 s
Iteration:  119 Progress:  14.88  % Time Elapsed:  252.52 s
Iteration:  120 Progress:  15.00  % Time Elapsed:  254.38 s
Epoch 2 Finished.  Time per Epoch:  84.79 s
Iteration:  121 Progress:  15.12  % Time Elapsed:  256.33 s
Iteration:  122 Progress:  15.25  % Time Elapsed:  258.35 s
Iteration:  123 Progress:  15.38  % Time Elapsed:  260.37 s
Iteration:  124 Progress:  15.50  % Time Elapsed:  262.36 s
Iteration:  125 Progress:  15.62  % Time Elapsed:  264.48 s
Iteration:  126 Progress:  15.75  % Time Elapsed:  266.51 s
Iteration:  127 Progress:  15.88  % Time Elapsed:  268.56 s
Iteration:  128 Progress:  16.00  % Time Elapsed:  270.49 s
Iteration:  129 Progress:  16.12  % Time Elapsed:  272.52 s
Iteration:  130 Progress:  16.25  % Time Elapsed:  274.63 s
Iteration:  131 Progress:  16.38  % Time Elapsed:  276.70 s
Iteration:  132 Progress:  16.50  % Time Elapsed:  278.72 s
Iteration:  133 Progress:  16.62  % Time Elapsed:  280.77 s
Iteration:  134 Progress:  16.75  % Time Elapsed:  282.74 s
Iteration:  135 Progress:  16.88  % Time Elapsed:  284.84 s
Iteration:  136 Progress:  17.00  % Time Elapsed:  286.91 s
Iteration:  137 Progress:  17.12  % Time Elapsed:  289.11 s
Iteration:  138 Progress:  17.25  % Time Elapsed:  291.27 s
Iteration:  139 Progress:  17.38  % Time Elapsed:  293.40 s
Iteration:  140 Progress:  17.50  % Time Elapsed:  295.47 s
Iteration:  141 Progress:  17.62  % Time Elapsed:  297.48 s
Iteration:  142 Progress:  17.75  % Time Elapsed:  299.47 s
Iteration:  143 Progress:  17.88  % Time Elapsed:  301.61 s
Iteration:  144 Progress:  18.00  % Time Elapsed:  303.71 s
Iteration:  145 Progress:  18.12  % Time Elapsed:  305.90 s
Iteration:  146 Progress:  18.25  % Time Elapsed:  308.07 s
Iteration:  147 Progress:  18.38  % Time Elapsed:  310.17 s
Iteration:  148 Progress:  18.50  % Time Elapsed:  312.08 s
Iteration:  149 Progress:  18.62  % Time Elapsed:  314.16 s
Iteration:  150 Progress:  18.75  % Time Elapsed:  316.30 s
Iteration:  151 Progress:  18.88  % Time Elapsed:  318.31 s
Iteration:  152 Progress:  19.00  % Time Elapsed:  320.45 s
Iteration:  153 Progress:  19.12  % Time Elapsed:  322.43 s
Iteration:  154 Progress:  19.25  % Time Elapsed:  324.41 s
Iteration:  155 Progress:  19.38  % Time Elapsed:  326.71 s
Iteration:  156 Progress:  19.50  % Time Elapsed:  328.91 s
Iteration:  157 Progress:  19.62  % Time Elapsed:  331.19 s
Iteration:  158 Progress:  19.75  % Time Elapsed:  333.45 s
Iteration:  159 Progress:  19.88  % Time Elapsed:  335.56 s
Iteration:  160 Progress:  20.00  % Time Elapsed:  337.51 s
Epoch 3 Finished.  Time per Epoch:  84.38 s
Iteration:  161 Progress:  20.12  % Time Elapsed:  339.98 s
Iteration:  162 Progress:  20.25  % Time Elapsed:  342.69 s
Iteration:  163 Progress:  20.38  % Time Elapsed:  344.88 s
```

```
Iteration:  164 Progress:  20.50  % Time Elapsed:  346.83 s
Iteration:  165 Progress:  20.62  % Time Elapsed:  348.78 s
Iteration:  166 Progress:  20.75  % Time Elapsed:  350.84 s
Iteration:  167 Progress:  20.88  % Time Elapsed:  353.08 s
Iteration:  168 Progress:  21.00  % Time Elapsed:  355.50 s
Iteration:  169 Progress:  21.12  % Time Elapsed:  357.67 s
Iteration:  170 Progress:  21.25  % Time Elapsed:  359.68 s
Iteration:  171 Progress:  21.38  % Time Elapsed:  361.68 s
Iteration:  172 Progress:  21.50  % Time Elapsed:  363.88 s
Iteration:  173 Progress:  21.62  % Time Elapsed:  366.08 s
Iteration:  174 Progress:  21.75  % Time Elapsed:  368.14 s
Iteration:  175 Progress:  21.88  % Time Elapsed:  371.09 s
Iteration:  176 Progress:  22.00  % Time Elapsed:  373.18 s
Iteration:  177 Progress:  22.12  % Time Elapsed:  375.23 s
Iteration:  178 Progress:  22.25  % Time Elapsed:  377.21 s
Iteration:  179 Progress:  22.38  % Time Elapsed:  379.28 s
Iteration:  180 Progress:  22.50  % Time Elapsed:  381.19 s
Iteration:  181 Progress:  22.62  % Time Elapsed:  383.15 s
Iteration:  182 Progress:  22.75  % Time Elapsed:  385.09 s
Iteration:  183 Progress:  22.88  % Time Elapsed:  387.08 s
Iteration:  184 Progress:  23.00  % Time Elapsed:  388.99 s
Iteration:  185 Progress:  23.12  % Time Elapsed:  390.94 s
Iteration:  186 Progress:  23.25  % Time Elapsed:  392.88 s
Iteration:  187 Progress:  23.38  % Time Elapsed:  394.84 s
Iteration:  188 Progress:  23.50  % Time Elapsed:  396.79 s
Iteration:  189 Progress:  23.62  % Time Elapsed:  398.78 s
Iteration:  190 Progress:  23.75  % Time Elapsed:  400.73 s
Iteration:  191 Progress:  23.88  % Time Elapsed:  402.72 s
Iteration:  192 Progress:  24.00  % Time Elapsed:  404.74 s
Iteration:  193 Progress:  24.12  % Time Elapsed:  406.82 s
Iteration:  194 Progress:  24.25  % Time Elapsed:  408.80 s
Iteration:  195 Progress:  24.38  % Time Elapsed:  410.96 s
Iteration:  196 Progress:  24.50  % Time Elapsed:  412.88 s
Iteration:  197 Progress:  24.62  % Time Elapsed:  414.82 s
Iteration:  198 Progress:  24.75  % Time Elapsed:  416.72 s
Iteration:  199 Progress:  24.88  % Time Elapsed:  418.73 s
Iteration:  200 Progress:  25.00  % Time Elapsed:  420.54 s
Epoch 4 Finished.  Time per Epoch:  84.11 s
Iteration:  201 Progress:  25.12  % Time Elapsed:  422.51 s
Iteration:  202 Progress:  25.25  % Time Elapsed:  424.70 s
Iteration:  203 Progress:  25.37  % Time Elapsed:  426.64 s
Iteration:  204 Progress:  25.50  % Time Elapsed:  428.63 s
Iteration:  205 Progress:  25.62  % Time Elapsed:  430.52 s
Iteration:  206 Progress:  25.75  % Time Elapsed:  432.48 s
Iteration:  207 Progress:  25.87  % Time Elapsed:  434.42 s
Iteration:  208 Progress:  26.00  % Time Elapsed:  436.47 s
Iteration:  209 Progress:  26.12  % Time Elapsed:  438.46 s
Iteration:  210 Progress:  26.25  % Time Elapsed:  440.47 s
Iteration:  211 Progress:  26.38  % Time Elapsed:  442.40 s
Iteration:  212 Progress:  26.50  % Time Elapsed:  444.36 s
Iteration:  213 Progress:  26.62  % Time Elapsed:  446.37 s
Iteration:  214 Progress:  26.75  % Time Elapsed:  448.44 s
Iteration:  215 Progress:  26.88  % Time Elapsed:  450.37 s
Iteration:  216 Progress:  27.00  % Time Elapsed:  452.27 s
Iteration:  217 Progress:  27.12  % Time Elapsed:  454.19 s
Iteration:  218 Progress:  27.25  % Time Elapsed:  456.15 s
```

```
Iteration:  219 Progress:  27.38  % Time Elapsed:  458.09 s
Iteration:  220 Progress:  27.50  % Time Elapsed:  460.11 s
Iteration:  221 Progress:  27.62  % Time Elapsed:  462.07 s
Iteration:  222 Progress:  27.75  % Time Elapsed:  464.03 s
Iteration:  223 Progress:  27.88  % Time Elapsed:  466.14 s
Iteration:  224 Progress:  28.00  % Time Elapsed:  468.19 s
Iteration:  225 Progress:  28.12  % Time Elapsed:  470.18 s
Iteration:  226 Progress:  28.25  % Time Elapsed:  472.16 s
Iteration:  227 Progress:  28.38  % Time Elapsed:  474.16 s
Iteration:  228 Progress:  28.50  % Time Elapsed:  476.56 s
Iteration:  229 Progress:  28.62  % Time Elapsed:  478.52 s
Iteration:  230 Progress:  28.75  % Time Elapsed:  480.67 s
Iteration:  231 Progress:  28.88  % Time Elapsed:  482.66 s
Iteration:  232 Progress:  29.00  % Time Elapsed:  484.71 s
Iteration:  233 Progress:  29.12  % Time Elapsed:  487.29 s
Iteration:  234 Progress:  29.25  % Time Elapsed:  489.33 s
Iteration:  235 Progress:  29.38  % Time Elapsed:  491.32 s
Iteration:  236 Progress:  29.50  % Time Elapsed:  493.39 s
Iteration:  237 Progress:  29.62  % Time Elapsed:  495.44 s
Iteration:  238 Progress:  29.75  % Time Elapsed:  497.51 s
Iteration:  239 Progress:  29.88  % Time Elapsed:  499.57 s
Iteration:  240 Progress:  30.00  % Time Elapsed:  501.49 s
Epoch 5 Finished.  Time per Epoch:  83.58 s
Iteration:  241 Progress:  30.12  % Time Elapsed:  503.48 s
Iteration:  242 Progress:  30.25  % Time Elapsed:  505.51 s
Iteration:  243 Progress:  30.38  % Time Elapsed:  507.58 s
Iteration:  244 Progress:  30.50  % Time Elapsed:  509.61 s
Iteration:  245 Progress:  30.63  % Time Elapsed:  511.68 s
Iteration:  246 Progress:  30.75  % Time Elapsed:  513.70 s
Iteration:  247 Progress:  30.88  % Time Elapsed:  515.78 s
Iteration:  248 Progress:  31.00  % Time Elapsed:  517.80 s
Iteration:  249 Progress:  31.13  % Time Elapsed:  519.83 s
Iteration:  250 Progress:  31.25  % Time Elapsed:  521.91 s
Iteration:  251 Progress:  31.37  % Time Elapsed:  523.95 s
Iteration:  252 Progress:  31.50  % Time Elapsed:  525.97 s
Iteration:  253 Progress:  31.62  % Time Elapsed:  527.97 s
Iteration:  254 Progress:  31.75  % Time Elapsed:  530.03 s
Iteration:  255 Progress:  31.87  % Time Elapsed:  532.08 s
Iteration:  256 Progress:  32.00  % Time Elapsed:  534.00 s
Iteration:  257 Progress:  32.12  % Time Elapsed:  536.12 s
Iteration:  258 Progress:  32.25  % Time Elapsed:  538.11 s
Iteration:  259 Progress:  32.38  % Time Elapsed:  540.18 s
Iteration:  260 Progress:  32.50  % Time Elapsed:  542.16 s
Iteration:  261 Progress:  32.62  % Time Elapsed:  544.19 s
Iteration:  262 Progress:  32.75  % Time Elapsed:  546.23 s
Iteration:  263 Progress:  32.88  % Time Elapsed:  548.25 s
Iteration:  264 Progress:  33.00  % Time Elapsed:  550.31 s
Iteration:  265 Progress:  33.12  % Time Elapsed:  552.28 s
Iteration:  266 Progress:  33.25  % Time Elapsed:  554.30 s
Iteration:  267 Progress:  33.38  % Time Elapsed:  556.31 s
Iteration:  268 Progress:  33.50  % Time Elapsed:  558.27 s
Iteration:  269 Progress:  33.62  % Time Elapsed:  560.38 s
Iteration:  270 Progress:  33.75  % Time Elapsed:  562.61 s
Iteration:  271 Progress:  33.88  % Time Elapsed:  564.64 s
Iteration:  272 Progress:  34.00  % Time Elapsed:  566.62 s
Iteration:  273 Progress:  34.12  % Time Elapsed:  568.65 s
```

```
Iteration:  274 Progress:  34.25  % Time Elapsed:  570.66 s
Iteration:  275 Progress:  34.38  % Time Elapsed:  572.69 s
Iteration:  276 Progress:  34.50  % Time Elapsed:  574.65 s
Iteration:  277 Progress:  34.62  % Time Elapsed:  576.67 s
Iteration:  278 Progress:  34.75  % Time Elapsed:  578.66 s
Iteration:  279 Progress:  34.88  % Time Elapsed:  580.66 s
Iteration:  280 Progress:  35.00  % Time Elapsed:  582.48 s
Epoch 6 Finished.  Time per Epoch:  83.21 s
Iteration:  281 Progress:  35.12  % Time Elapsed:  584.49 s
Iteration:  282 Progress:  35.25  % Time Elapsed:  586.51 s
Iteration:  283 Progress:  35.38  % Time Elapsed:  588.46 s
Iteration:  284 Progress:  35.50  % Time Elapsed:  590.52 s
Iteration:  285 Progress:  35.62  % Time Elapsed:  592.48 s
Iteration:  286 Progress:  35.75  % Time Elapsed:  594.47 s
Iteration:  287 Progress:  35.88  % Time Elapsed:  596.41 s
Iteration:  288 Progress:  36.00  % Time Elapsed:  598.44 s
Iteration:  289 Progress:  36.12  % Time Elapsed:  600.51 s
Iteration:  290 Progress:  36.25  % Time Elapsed:  602.44 s
Iteration:  291 Progress:  36.38  % Time Elapsed:  604.47 s
Iteration:  292 Progress:  36.50  % Time Elapsed:  606.52 s
Iteration:  293 Progress:  36.62  % Time Elapsed:  608.48 s
Iteration:  294 Progress:  36.75  % Time Elapsed:  610.51 s
Iteration:  295 Progress:  36.88  % Time Elapsed:  612.46 s
Iteration:  296 Progress:  37.00  % Time Elapsed:  614.50 s
Iteration:  297 Progress:  37.12  % Time Elapsed:  616.41 s
Iteration:  298 Progress:  37.25  % Time Elapsed:  618.48 s
Iteration:  299 Progress:  37.38  % Time Elapsed:  620.50 s
Iteration:  300 Progress:  37.50  % Time Elapsed:  622.49 s
Iteration:  301 Progress:  37.62  % Time Elapsed:  624.47 s
Iteration:  302 Progress:  37.75  % Time Elapsed:  626.48 s
Iteration:  303 Progress:  37.88  % Time Elapsed:  628.52 s
Iteration:  304 Progress:  38.00  % Time Elapsed:  630.49 s
Iteration:  305 Progress:  38.12  % Time Elapsed:  632.59 s
Iteration:  306 Progress:  38.25  % Time Elapsed:  634.66 s
Iteration:  307 Progress:  38.38  % Time Elapsed:  636.66 s
Iteration:  308 Progress:  38.50  % Time Elapsed:  638.73 s
Iteration:  309 Progress:  38.62  % Time Elapsed:  640.75 s
Iteration:  310 Progress:  38.75  % Time Elapsed:  642.76 s
Iteration:  311 Progress:  38.88  % Time Elapsed:  644.75 s
Iteration:  312 Progress:  39.00  % Time Elapsed:  646.84 s
Iteration:  313 Progress:  39.12  % Time Elapsed:  648.96 s
Iteration:  314 Progress:  39.25  % Time Elapsed:  651.06 s
Iteration:  315 Progress:  39.38  % Time Elapsed:  653.11 s
Iteration:  316 Progress:  39.50  % Time Elapsed:  655.19 s
Iteration:  317 Progress:  39.62  % Time Elapsed:  657.15 s
Iteration:  318 Progress:  39.75  % Time Elapsed:  659.28 s
Iteration:  319 Progress:  39.88  % Time Elapsed:  661.38 s
Iteration:  320 Progress:  40.00  % Time Elapsed:  663.31 s
Epoch 7 Finished.  Time per Epoch:  82.91 s
Iteration:  321 Progress:  40.12  % Time Elapsed:  665.53 s
Iteration:  322 Progress:  40.25  % Time Elapsed:  667.68 s
Iteration:  323 Progress:  40.38  % Time Elapsed:  669.87 s
Iteration:  324 Progress:  40.50  % Time Elapsed:  671.84 s
Iteration:  325 Progress:  40.62  % Time Elapsed:  673.98 s
Iteration:  326 Progress:  40.75  % Time Elapsed:  676.03 s
Iteration:  327 Progress:  40.88  % Time Elapsed:  678.04 s
```

```
Iteration:  328 Progress:  41.00  % Time Elapsed:  680.04 s
Iteration:  329 Progress:  41.12  % Time Elapsed:  681.99 s
Iteration:  330 Progress:  41.25  % Time Elapsed:  683.98 s
Iteration:  331 Progress:  41.38  % Time Elapsed:  685.93 s
Iteration:  332 Progress:  41.50  % Time Elapsed:  687.96 s
Iteration:  333 Progress:  41.62  % Time Elapsed:  690.01 s
Iteration:  334 Progress:  41.75  % Time Elapsed:  692.02 s
Iteration:  335 Progress:  41.88  % Time Elapsed:  694.01 s
Iteration:  336 Progress:  42.00  % Time Elapsed:  696.01 s
Iteration:  337 Progress:  42.12  % Time Elapsed:  698.19 s
Iteration:  338 Progress:  42.25  % Time Elapsed:  700.33 s
Iteration:  339 Progress:  42.38  % Time Elapsed:  702.36 s
Iteration:  340 Progress:  42.50  % Time Elapsed:  704.35 s
Iteration:  341 Progress:  42.62  % Time Elapsed:  706.39 s
Iteration:  342 Progress:  42.75  % Time Elapsed:  708.44 s
Iteration:  343 Progress:  42.88  % Time Elapsed:  710.49 s
Iteration:  344 Progress:  43.00  % Time Elapsed:  712.42 s
Iteration:  345 Progress:  43.12  % Time Elapsed:  714.51 s
Iteration:  346 Progress:  43.25  % Time Elapsed:  716.50 s
Iteration:  347 Progress:  43.38  % Time Elapsed:  718.51 s
Iteration:  348 Progress:  43.50  % Time Elapsed:  720.56 s
Iteration:  349 Progress:  43.62  % Time Elapsed:  722.52 s
Iteration:  350 Progress:  43.75  % Time Elapsed:  724.56 s
Iteration:  351 Progress:  43.88  % Time Elapsed:  726.53 s
Iteration:  352 Progress:  44.00  % Time Elapsed:  728.61 s
Iteration:  353 Progress:  44.12  % Time Elapsed:  730.61 s
Iteration:  354 Progress:  44.25  % Time Elapsed:  732.66 s
Iteration:  355 Progress:  44.38  % Time Elapsed:  734.66 s
Iteration:  356 Progress:  44.50  % Time Elapsed:  736.70 s
Iteration:  357 Progress:  44.62  % Time Elapsed:  738.73 s
Iteration:  358 Progress:  44.75  % Time Elapsed:  740.75 s
Iteration:  359 Progress:  44.88  % Time Elapsed:  742.81 s
Iteration:  360 Progress:  45.00  % Time Elapsed:  744.78 s
Epoch 8 Finished.  Time per Epoch:  82.75 s
Iteration:  361 Progress:  45.12  % Time Elapsed:  746.79 s
Iteration:  362 Progress:  45.25  % Time Elapsed:  748.80 s
Iteration:  363 Progress:  45.38  % Time Elapsed:  750.83 s
Iteration:  364 Progress:  45.50  % Time Elapsed:  752.85 s
Iteration:  365 Progress:  45.62  % Time Elapsed:  754.80 s
Iteration:  366 Progress:  45.75  % Time Elapsed:  756.84 s
Iteration:  367 Progress:  45.88  % Time Elapsed:  758.91 s
Iteration:  368 Progress:  46.00  % Time Elapsed:  760.91 s
Iteration:  369 Progress:  46.12  % Time Elapsed:  762.93 s
Iteration:  370 Progress:  46.25  % Time Elapsed:  764.91 s
Iteration:  371 Progress:  46.38  % Time Elapsed:  766.92 s
Iteration:  372 Progress:  46.50  % Time Elapsed:  768.93 s
Iteration:  373 Progress:  46.62  % Time Elapsed:  771.04 s
Iteration:  374 Progress:  46.75  % Time Elapsed:  773.03 s
Iteration:  375 Progress:  46.88  % Time Elapsed:  775.08 s
Iteration:  376 Progress:  47.00  % Time Elapsed:  777.05 s
Iteration:  377 Progress:  47.12  % Time Elapsed:  779.10 s
Iteration:  378 Progress:  47.25  % Time Elapsed:  781.10 s
Iteration:  379 Progress:  47.38  % Time Elapsed:  783.15 s
Iteration:  380 Progress:  47.50  % Time Elapsed:  785.17 s
Iteration:  381 Progress:  47.62  % Time Elapsed:  787.14 s
Iteration:  382 Progress:  47.75  % Time Elapsed:  789.16 s
```

```
Iteration:  383 Progress:  47.88  % Time Elapsed:  791.14 s
Iteration:  384 Progress:  48.00  % Time Elapsed:  793.16 s
Iteration:  385 Progress:  48.12  % Time Elapsed:  795.16 s
Iteration:  386 Progress:  48.25  % Time Elapsed:  797.25 s
Iteration:  387 Progress:  48.38  % Time Elapsed:  799.27 s
Iteration:  388 Progress:  48.50  % Time Elapsed:  801.28 s
Iteration:  389 Progress:  48.62  % Time Elapsed:  803.29 s
Iteration:  390 Progress:  48.75  % Time Elapsed:  805.30 s
Iteration:  391 Progress:  48.88  % Time Elapsed:  807.25 s
Iteration:  392 Progress:  49.00  % Time Elapsed:  809.30 s
Iteration:  393 Progress:  49.12  % Time Elapsed:  811.37 s
Iteration:  394 Progress:  49.25  % Time Elapsed:  813.39 s
Iteration:  395 Progress:  49.38  % Time Elapsed:  815.38 s
Iteration:  396 Progress:  49.50  % Time Elapsed:  817.37 s
Iteration:  397 Progress:  49.62  % Time Elapsed:  819.43 s
Iteration:  398 Progress:  49.75  % Time Elapsed:  821.45 s
Iteration:  399 Progress:  49.88  % Time Elapsed:  823.45 s
Iteration:  400 Progress:  50.00  % Time Elapsed:  825.43 s
Epoch 9 Finished.  Time per Epoch:  82.54 s
Iteration:  401 Progress:  50.12  % Time Elapsed:  827.42 s
Iteration:  402 Progress:  50.25  % Time Elapsed:  829.45 s
Iteration:  403 Progress:  50.38  % Time Elapsed:  831.46 s
Iteration:  404 Progress:  50.50  % Time Elapsed:  833.46 s
Iteration:  405 Progress:  50.62  % Time Elapsed:  835.43 s
Iteration:  406 Progress:  50.75  % Time Elapsed:  837.64 s
Iteration:  407 Progress:  50.88  % Time Elapsed:  839.69 s
Iteration:  408 Progress:  51.00  % Time Elapsed:  841.65 s
Iteration:  409 Progress:  51.12  % Time Elapsed:  843.63 s
Iteration:  410 Progress:  51.25  % Time Elapsed:  845.63 s
Iteration:  411 Progress:  51.38  % Time Elapsed:  847.60 s
Iteration:  412 Progress:  51.50  % Time Elapsed:  849.60 s
Iteration:  413 Progress:  51.62  % Time Elapsed:  851.53 s
Iteration:  414 Progress:  51.75  % Time Elapsed:  853.54 s
Iteration:  415 Progress:  51.88  % Time Elapsed:  855.52 s
Iteration:  416 Progress:  52.00  % Time Elapsed:  857.47 s
Iteration:  417 Progress:  52.12  % Time Elapsed:  859.47 s
Iteration:  418 Progress:  52.25  % Time Elapsed:  861.46 s
Iteration:  419 Progress:  52.38  % Time Elapsed:  863.48 s
Iteration:  420 Progress:  52.50  % Time Elapsed:  865.41 s
Iteration:  421 Progress:  52.62  % Time Elapsed:  867.38 s
Iteration:  422 Progress:  52.75  % Time Elapsed:  869.38 s
Iteration:  423 Progress:  52.88  % Time Elapsed:  871.44 s
Iteration:  424 Progress:  53.00  % Time Elapsed:  873.42 s
Iteration:  425 Progress:  53.12  % Time Elapsed:  875.41 s
Iteration:  426 Progress:  53.25  % Time Elapsed:  877.43 s
Iteration:  427 Progress:  53.37  % Time Elapsed:  879.45 s
Iteration:  428 Progress:  53.50  % Time Elapsed:  881.45 s
Iteration:  429 Progress:  53.62  % Time Elapsed:  883.49 s
Iteration:  430 Progress:  53.75  % Time Elapsed:  885.50 s
Iteration:  431 Progress:  53.87  % Time Elapsed:  887.45 s
Iteration:  432 Progress:  54.00  % Time Elapsed:  889.42 s
Iteration:  433 Progress:  54.12  % Time Elapsed:  891.40 s
Iteration:  434 Progress:  54.25  % Time Elapsed:  893.49 s
Iteration:  435 Progress:  54.37  % Time Elapsed:  895.49 s
Iteration:  436 Progress:  54.50  % Time Elapsed:  897.49 s
Iteration:  437 Progress:  54.62  % Time Elapsed:  899.55 s
```

```
Iteration:  438 Progress:  54.75  % Time Elapsed:  901.58 s
Iteration:  439 Progress:  54.87  % Time Elapsed:  903.56 s
Iteration:  440 Progress:  55.00  % Time Elapsed:  905.40 s
Epoch 10 Finished.  Time per Epoch:  82.31 s
Iteration:  441 Progress:  55.12  % Time Elapsed:  907.42 s
Iteration:  442 Progress:  55.25  % Time Elapsed:  909.35 s
Iteration:  443 Progress:  55.38  % Time Elapsed:  911.35 s
Iteration:  444 Progress:  55.50  % Time Elapsed:  913.32 s
Iteration:  445 Progress:  55.62  % Time Elapsed:  915.32 s
Iteration:  446 Progress:  55.75  % Time Elapsed:  917.26 s
Iteration:  447 Progress:  55.88  % Time Elapsed:  919.20 s
Iteration:  448 Progress:  56.00  % Time Elapsed:  921.20 s
Iteration:  449 Progress:  56.12  % Time Elapsed:  923.18 s
Iteration:  450 Progress:  56.25  % Time Elapsed:  925.16 s
Iteration:  451 Progress:  56.38  % Time Elapsed:  927.13 s
Iteration:  452 Progress:  56.50  % Time Elapsed:  929.08 s
Iteration:  453 Progress:  56.62  % Time Elapsed:  931.09 s
Iteration:  454 Progress:  56.75  % Time Elapsed:  932.97 s
Iteration:  455 Progress:  56.88  % Time Elapsed:  935.00 s
Iteration:  456 Progress:  57.00  % Time Elapsed:  936.90 s
Iteration:  457 Progress:  57.12  % Time Elapsed:  938.85 s
Iteration:  458 Progress:  57.25  % Time Elapsed:  940.76 s
Iteration:  459 Progress:  57.38  % Time Elapsed:  942.72 s
Iteration:  460 Progress:  57.50  % Time Elapsed:  944.72 s
Iteration:  461 Progress:  57.63  % Time Elapsed:  946.68 s
Iteration:  462 Progress:  57.75  % Time Elapsed:  948.67 s
Iteration:  463 Progress:  57.88  % Time Elapsed:  950.65 s
Iteration:  464 Progress:  58.00  % Time Elapsed:  952.59 s
Iteration:  465 Progress:  58.13  % Time Elapsed:  954.56 s
Iteration:  466 Progress:  58.25  % Time Elapsed:  956.54 s
Iteration:  467 Progress:  58.38  % Time Elapsed:  958.50 s
Iteration:  468 Progress:  58.50  % Time Elapsed:  960.50 s
Iteration:  469 Progress:  58.63  % Time Elapsed:  962.54 s
Iteration:  470 Progress:  58.75  % Time Elapsed:  964.53 s
Iteration:  471 Progress:  58.88  % Time Elapsed:  966.62 s
Iteration:  472 Progress:  59.00  % Time Elapsed:  968.86 s
Iteration:  473 Progress:  59.13  % Time Elapsed:  971.04 s
Iteration:  474 Progress:  59.25  % Time Elapsed:  973.13 s
Iteration:  475 Progress:  59.38  % Time Elapsed:  975.57 s
Iteration:  476 Progress:  59.50  % Time Elapsed:  977.69 s
Iteration:  477 Progress:  59.62  % Time Elapsed:  979.82 s
Iteration:  478 Progress:  59.75  % Time Elapsed:  981.87 s
Iteration:  479 Progress:  59.88  % Time Elapsed:  984.02 s
Iteration:  480 Progress:  60.00  % Time Elapsed:  986.02 s
Epoch 11 Finished.  Time per Epoch:  82.17 s
Iteration:  481 Progress:  60.12  % Time Elapsed:  988.01 s
Iteration:  482 Progress:  60.25  % Time Elapsed:  990.18 s
Iteration:  483 Progress:  60.38  % Time Elapsed:  992.29 s
Iteration:  484 Progress:  60.50  % Time Elapsed:  994.35 s
Iteration:  485 Progress:  60.62  % Time Elapsed:  996.35 s
Iteration:  486 Progress:  60.75  % Time Elapsed:  998.32 s
Iteration:  487 Progress:  60.88  % Time Elapsed:  1000.31 s
Iteration:  488 Progress:  61.00  % Time Elapsed:  1002.18 s
Iteration:  489 Progress:  61.12  % Time Elapsed:  1004.20 s
Iteration:  490 Progress:  61.25  % Time Elapsed:  1006.14 s
Iteration:  491 Progress:  61.38  % Time Elapsed:  1008.05 s
```

```
Iteration:  492 Progress:  61.50  % Time Elapsed:  1010.00 s
Iteration:  493 Progress:  61.62  % Time Elapsed:  1011.91 s
Iteration:  494 Progress:  61.75  % Time Elapsed:  1013.83 s
Iteration:  495 Progress:  61.88  % Time Elapsed:  1015.71 s
Iteration:  496 Progress:  62.00  % Time Elapsed:  1017.62 s
Iteration:  497 Progress:  62.12  % Time Elapsed:  1019.54 s
Iteration:  498 Progress:  62.25  % Time Elapsed:  1021.43 s
Iteration:  499 Progress:  62.38  % Time Elapsed:  1023.30 s
Iteration:  500 Progress:  62.50  % Time Elapsed:  1025.27 s
Iteration:  501 Progress:  62.62  % Time Elapsed:  1027.12 s
Iteration:  502 Progress:  62.75  % Time Elapsed:  1028.95 s
Iteration:  503 Progress:  62.88  % Time Elapsed:  1030.86 s
Iteration:  504 Progress:  63.00  % Time Elapsed:  1032.76 s
Iteration:  505 Progress:  63.12  % Time Elapsed:  1034.65 s
Iteration:  506 Progress:  63.25  % Time Elapsed:  1036.52 s
Iteration:  507 Progress:  63.38  % Time Elapsed:  1038.39 s
Iteration:  508 Progress:  63.50  % Time Elapsed:  1040.30 s
Iteration:  509 Progress:  63.62  % Time Elapsed:  1042.14 s
Iteration:  510 Progress:  63.75  % Time Elapsed:  1044.00 s
Iteration:  511 Progress:  63.88  % Time Elapsed:  1045.93 s
Iteration:  512 Progress:  64.00  % Time Elapsed:  1047.89 s
Iteration:  513 Progress:  64.12  % Time Elapsed:  1049.83 s
Iteration:  514 Progress:  64.25  % Time Elapsed:  1051.74 s
Iteration:  515 Progress:  64.38  % Time Elapsed:  1053.65 s
Iteration:  516 Progress:  64.50  % Time Elapsed:  1055.63 s
Iteration:  517 Progress:  64.62  % Time Elapsed:  1057.47 s
Iteration:  518 Progress:  64.75  % Time Elapsed:  1059.42 s
Iteration:  519 Progress:  64.88  % Time Elapsed:  1061.30 s
Iteration:  520 Progress:  65.00  % Time Elapsed:  1063.07 s
Epoch 12 Finished.  Time per Epoch:  81.77 s
Iteration:  521 Progress:  65.12  % Time Elapsed:  1064.93 s
Iteration:  522 Progress:  65.25  % Time Elapsed:  1066.81 s
Iteration:  523 Progress:  65.38  % Time Elapsed:  1068.70 s
Iteration:  524 Progress:  65.50  % Time Elapsed:  1070.54 s
Iteration:  525 Progress:  65.62  % Time Elapsed:  1072.47 s
Iteration:  526 Progress:  65.75  % Time Elapsed:  1074.36 s
Iteration:  527 Progress:  65.88  % Time Elapsed:  1076.22 s
Iteration:  528 Progress:  66.00  % Time Elapsed:  1078.10 s
Iteration:  529 Progress:  66.12  % Time Elapsed:  1080.06 s
Iteration:  530 Progress:  66.25  % Time Elapsed:  1081.93 s
Iteration:  531 Progress:  66.38  % Time Elapsed:  1083.76 s
Iteration:  532 Progress:  66.50  % Time Elapsed:  1085.64 s
Iteration:  533 Progress:  66.62  % Time Elapsed:  1087.53 s
Iteration:  534 Progress:  66.75  % Time Elapsed:  1089.48 s
Iteration:  535 Progress:  66.88  % Time Elapsed:  1091.39 s
Iteration:  536 Progress:  67.00  % Time Elapsed:  1093.31 s
Iteration:  537 Progress:  67.12  % Time Elapsed:  1095.22 s
Iteration:  538 Progress:  67.25  % Time Elapsed:  1097.11 s
Iteration:  539 Progress:  67.38  % Time Elapsed:  1098.94 s
Iteration:  540 Progress:  67.50  % Time Elapsed:  1100.88 s
Iteration:  541 Progress:  67.62  % Time Elapsed:  1102.78 s
Iteration:  542 Progress:  67.75  % Time Elapsed:  1104.68 s
Iteration:  543 Progress:  67.88  % Time Elapsed:  1106.58 s
Iteration:  544 Progress:  68.00  % Time Elapsed:  1108.50 s
Iteration:  545 Progress:  68.12  % Time Elapsed:  1111.16 s
Iteration:  546 Progress:  68.25  % Time Elapsed:  1113.82 s
```

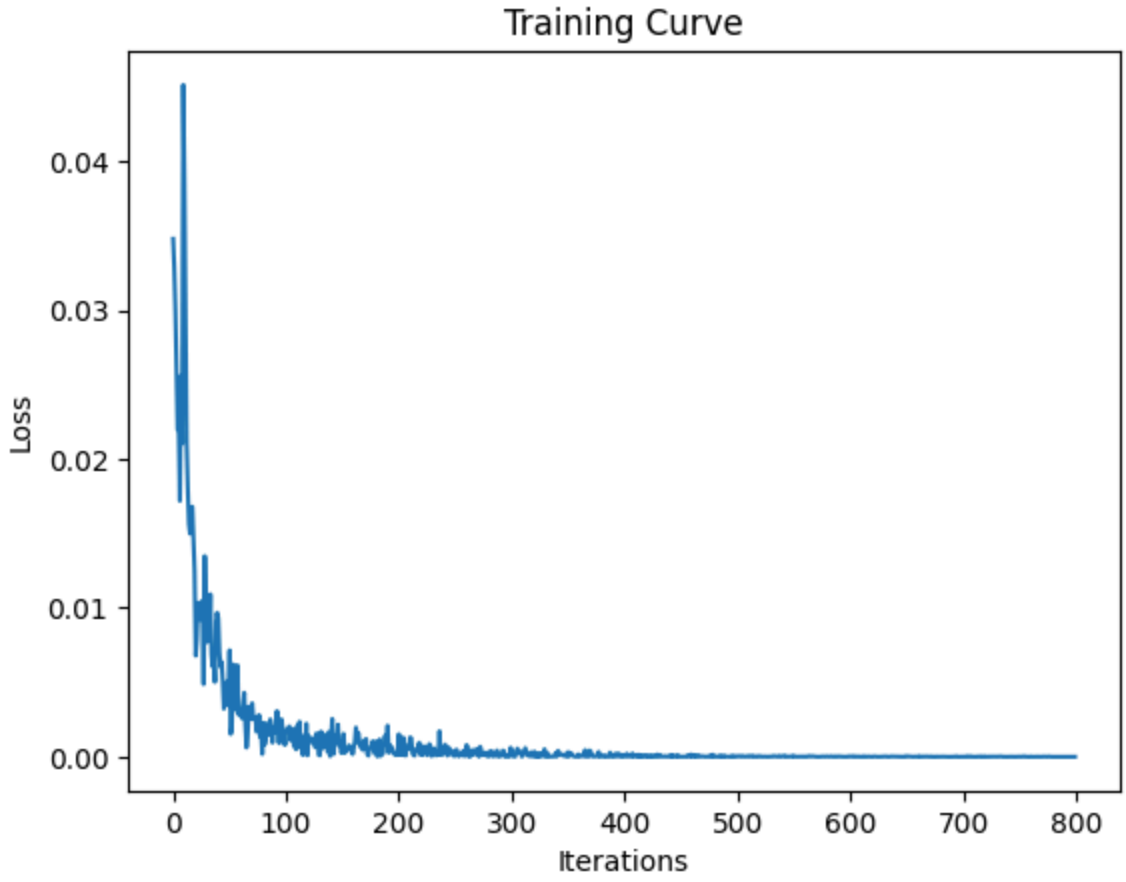
```
Iteration:  547 Progress:  68.38  % Time Elapsed:  1115.73 s
Iteration:  548 Progress:  68.50  % Time Elapsed:  1117.67 s
Iteration:  549 Progress:  68.62  % Time Elapsed:  1119.62 s
Iteration:  550 Progress:  68.75  % Time Elapsed:  1121.51 s
Iteration:  551 Progress:  68.88  % Time Elapsed:  1123.44 s
Iteration:  552 Progress:  69.00  % Time Elapsed:  1125.38 s
Iteration:  553 Progress:  69.12  % Time Elapsed:  1127.34 s
Iteration:  554 Progress:  69.25  % Time Elapsed:  1129.30 s
Iteration:  555 Progress:  69.38  % Time Elapsed:  1131.21 s
Iteration:  556 Progress:  69.50  % Time Elapsed:  1133.13 s
Iteration:  557 Progress:  69.62  % Time Elapsed:  1135.06 s
Iteration:  558 Progress:  69.75  % Time Elapsed:  1136.94 s
Iteration:  559 Progress:  69.88  % Time Elapsed:  1139.16 s
Iteration:  560 Progress:  70.00  % Time Elapsed:  1142.08 s
Epoch 13 Finished.  Time per Epoch:  81.58 s
Iteration:  561 Progress:  70.12  % Time Elapsed:  1144.33 s
Iteration:  562 Progress:  70.25  % Time Elapsed:  1146.29 s
Iteration:  563 Progress:  70.38  % Time Elapsed:  1148.23 s
Iteration:  564 Progress:  70.50  % Time Elapsed:  1150.20 s
Iteration:  565 Progress:  70.62  % Time Elapsed:  1152.15 s
Iteration:  566 Progress:  70.75  % Time Elapsed:  1154.01 s
Iteration:  567 Progress:  70.88  % Time Elapsed:  1156.01 s
Iteration:  568 Progress:  71.00  % Time Elapsed:  1157.90 s
Iteration:  569 Progress:  71.12  % Time Elapsed:  1159.83 s
Iteration:  570 Progress:  71.25  % Time Elapsed:  1161.74 s
Iteration:  571 Progress:  71.38  % Time Elapsed:  1163.63 s
Iteration:  572 Progress:  71.50  % Time Elapsed:  1165.57 s
Iteration:  573 Progress:  71.62  % Time Elapsed:  1167.43 s
Iteration:  574 Progress:  71.75  % Time Elapsed:  1169.49 s
Iteration:  575 Progress:  71.88  % Time Elapsed:  1171.46 s
Iteration:  576 Progress:  72.00  % Time Elapsed:  1173.34 s
Iteration:  577 Progress:  72.12  % Time Elapsed:  1175.29 s
Iteration:  578 Progress:  72.25  % Time Elapsed:  1177.18 s
Iteration:  579 Progress:  72.38  % Time Elapsed:  1179.19 s
Iteration:  580 Progress:  72.50  % Time Elapsed:  1181.07 s
Iteration:  581 Progress:  72.62  % Time Elapsed:  1183.01 s
Iteration:  582 Progress:  72.75  % Time Elapsed:  1184.94 s
Iteration:  583 Progress:  72.88  % Time Elapsed:  1186.88 s
Iteration:  584 Progress:  73.00  % Time Elapsed:  1188.77 s
Iteration:  585 Progress:  73.12  % Time Elapsed:  1190.71 s
Iteration:  586 Progress:  73.25  % Time Elapsed:  1192.58 s
Iteration:  587 Progress:  73.38  % Time Elapsed:  1194.51 s
Iteration:  588 Progress:  73.50  % Time Elapsed:  1196.38 s
Iteration:  589 Progress:  73.62  % Time Elapsed:  1198.32 s
Iteration:  590 Progress:  73.75  % Time Elapsed:  1200.34 s
Iteration:  591 Progress:  73.88  % Time Elapsed:  1202.24 s
Iteration:  592 Progress:  74.00  % Time Elapsed:  1204.20 s
Iteration:  593 Progress:  74.12  % Time Elapsed:  1206.15 s
Iteration:  594 Progress:  74.25  % Time Elapsed:  1208.06 s
Iteration:  595 Progress:  74.38  % Time Elapsed:  1209.97 s
Iteration:  596 Progress:  74.50  % Time Elapsed:  1211.87 s
Iteration:  597 Progress:  74.62  % Time Elapsed:  1213.81 s
Iteration:  598 Progress:  74.75  % Time Elapsed:  1215.76 s
Iteration:  599 Progress:  74.88  % Time Elapsed:  1217.67 s
Iteration:  600 Progress:  75.00  % Time Elapsed:  1219.49 s
Epoch 14 Finished.  Time per Epoch:  81.30 s
```

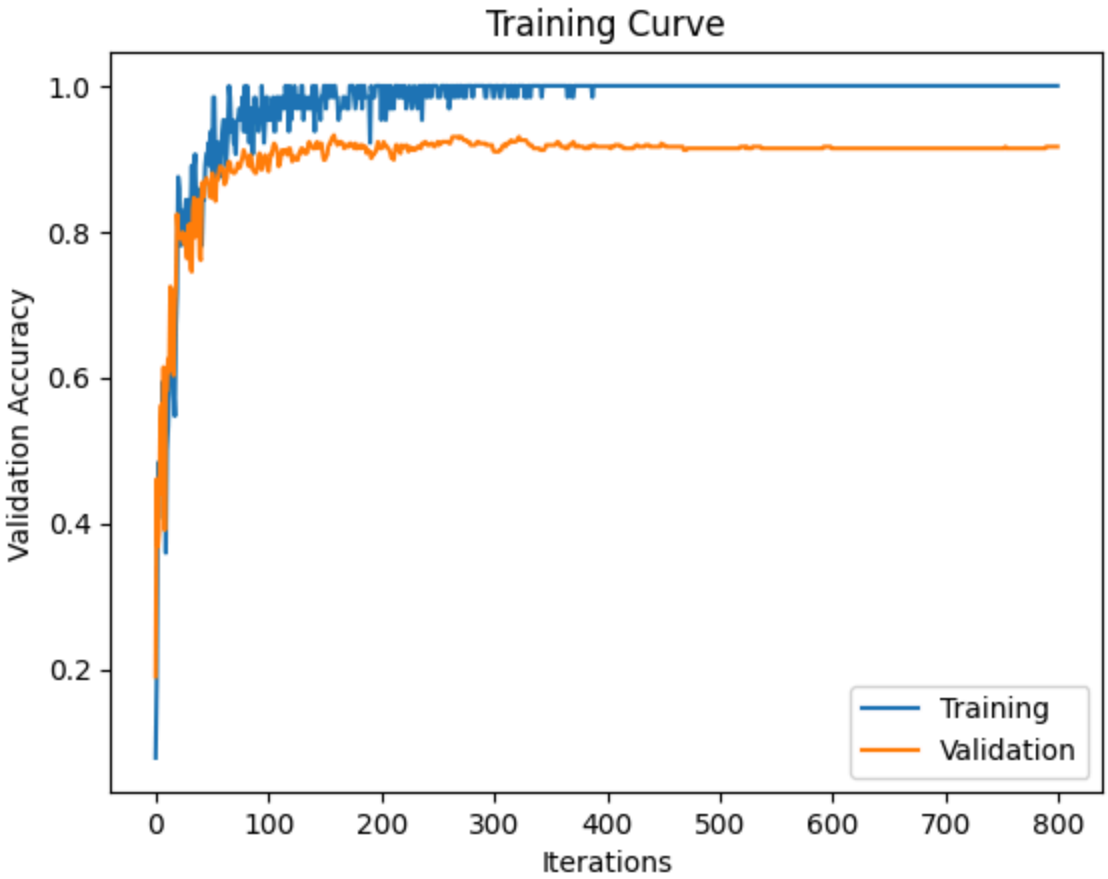
```
Iteration:  601 Progress:  75.12  % Time Elapsed:  1221.38 s
Iteration:  602 Progress:  75.25  % Time Elapsed:  1223.21 s
Iteration:  603 Progress:  75.38  % Time Elapsed:  1225.23 s
Iteration:  604 Progress:  75.50  % Time Elapsed:  1227.12 s
Iteration:  605 Progress:  75.62  % Time Elapsed:  1229.07 s
Iteration:  606 Progress:  75.75  % Time Elapsed:  1231.09 s
Iteration:  607 Progress:  75.88  % Time Elapsed:  1233.03 s
Iteration:  608 Progress:  76.00  % Time Elapsed:  1234.96 s
Iteration:  609 Progress:  76.12  % Time Elapsed:  1236.77 s
Iteration:  610 Progress:  76.25  % Time Elapsed:  1238.79 s
Iteration:  611 Progress:  76.38  % Time Elapsed:  1240.75 s
Iteration:  612 Progress:  76.50  % Time Elapsed:  1242.61 s
Iteration:  613 Progress:  76.62  % Time Elapsed:  1244.52 s
Iteration:  614 Progress:  76.75  % Time Elapsed:  1246.48 s
Iteration:  615 Progress:  76.88  % Time Elapsed:  1248.42 s
Iteration:  616 Progress:  77.00  % Time Elapsed:  1250.24 s
Iteration:  617 Progress:  77.12  % Time Elapsed:  1252.12 s
Iteration:  618 Progress:  77.25  % Time Elapsed:  1254.01 s
Iteration:  619 Progress:  77.38  % Time Elapsed:  1255.91 s
Iteration:  620 Progress:  77.50  % Time Elapsed:  1257.78 s
Iteration:  621 Progress:  77.62  % Time Elapsed:  1259.69 s
Iteration:  622 Progress:  77.75  % Time Elapsed:  1261.66 s
Iteration:  623 Progress:  77.88  % Time Elapsed:  1263.53 s
Iteration:  624 Progress:  78.00  % Time Elapsed:  1265.50 s
Iteration:  625 Progress:  78.12  % Time Elapsed:  1267.44 s
Iteration:  626 Progress:  78.25  % Time Elapsed:  1269.42 s
Iteration:  627 Progress:  78.38  % Time Elapsed:  1271.36 s
Iteration:  628 Progress:  78.50  % Time Elapsed:  1273.28 s
Iteration:  629 Progress:  78.62  % Time Elapsed:  1275.27 s
Iteration:  630 Progress:  78.75  % Time Elapsed:  1277.19 s
Iteration:  631 Progress:  78.88  % Time Elapsed:  1279.18 s
Iteration:  632 Progress:  79.00  % Time Elapsed:  1281.16 s
Iteration:  633 Progress:  79.12  % Time Elapsed:  1283.32 s
Iteration:  634 Progress:  79.25  % Time Elapsed:  1285.25 s
Iteration:  635 Progress:  79.38  % Time Elapsed:  1287.20 s
Iteration:  636 Progress:  79.50  % Time Elapsed:  1289.10 s
Iteration:  637 Progress:  79.62  % Time Elapsed:  1290.99 s
Iteration:  638 Progress:  79.75  % Time Elapsed:  1292.88 s
Iteration:  639 Progress:  79.88  % Time Elapsed:  1294.84 s
Iteration:  640 Progress:  80.00  % Time Elapsed:  1296.69 s
Epoch 15 Finished.  Time per Epoch:  81.04 s
Iteration:  641 Progress:  80.12  % Time Elapsed:  1298.64 s
Iteration:  642 Progress:  80.25  % Time Elapsed:  1300.61 s
Iteration:  643 Progress:  80.38  % Time Elapsed:  1302.54 s
Iteration:  644 Progress:  80.50  % Time Elapsed:  1304.49 s
Iteration:  645 Progress:  80.62  % Time Elapsed:  1306.40 s
Iteration:  646 Progress:  80.75  % Time Elapsed:  1308.37 s
Iteration:  647 Progress:  80.88  % Time Elapsed:  1310.35 s
Iteration:  648 Progress:  81.00  % Time Elapsed:  1312.26 s
Iteration:  649 Progress:  81.12  % Time Elapsed:  1314.21 s
Iteration:  650 Progress:  81.25  % Time Elapsed:  1316.08 s
Iteration:  651 Progress:  81.38  % Time Elapsed:  1318.00 s
Iteration:  652 Progress:  81.50  % Time Elapsed:  1319.91 s
Iteration:  653 Progress:  81.62  % Time Elapsed:  1321.89 s
Iteration:  654 Progress:  81.75  % Time Elapsed:  1323.81 s
Iteration:  655 Progress:  81.88  % Time Elapsed:  1325.74 s
```

```
Iteration:  656 Progress:  82.00  % Time Elapsed:  1327.69 s
Iteration:  657 Progress:  82.12  % Time Elapsed:  1329.59 s
Iteration:  658 Progress:  82.25  % Time Elapsed:  1331.55 s
Iteration:  659 Progress:  82.38  % Time Elapsed:  1333.49 s
Iteration:  660 Progress:  82.50  % Time Elapsed:  1335.43 s
Iteration:  661 Progress:  82.62  % Time Elapsed:  1337.35 s
Iteration:  662 Progress:  82.75  % Time Elapsed:  1339.28 s
Iteration:  663 Progress:  82.88  % Time Elapsed:  1341.24 s
Iteration:  664 Progress:  83.00  % Time Elapsed:  1343.16 s
Iteration:  665 Progress:  83.12  % Time Elapsed:  1345.08 s
Iteration:  666 Progress:  83.25  % Time Elapsed:  1347.00 s
Iteration:  667 Progress:  83.38  % Time Elapsed:  1348.94 s
Iteration:  668 Progress:  83.50  % Time Elapsed:  1350.99 s
Iteration:  669 Progress:  83.62  % Time Elapsed:  1352.97 s
Iteration:  670 Progress:  83.75  % Time Elapsed:  1354.91 s
Iteration:  671 Progress:  83.88  % Time Elapsed:  1356.91 s
Iteration:  672 Progress:  84.00  % Time Elapsed:  1358.87 s
Iteration:  673 Progress:  84.12  % Time Elapsed:  1360.70 s
Iteration:  674 Progress:  84.25  % Time Elapsed:  1362.68 s
Iteration:  675 Progress:  84.38  % Time Elapsed:  1364.62 s
Iteration:  676 Progress:  84.50  % Time Elapsed:  1366.63 s
Iteration:  677 Progress:  84.62  % Time Elapsed:  1368.63 s
Iteration:  678 Progress:  84.75  % Time Elapsed:  1370.57 s
Iteration:  679 Progress:  84.88  % Time Elapsed:  1372.48 s
Iteration:  680 Progress:  85.00  % Time Elapsed:  1374.20 s
Epoch 16 Finished.  Time per Epoch:  80.84 s
Iteration:  681 Progress:  85.12  % Time Elapsed:  1376.10 s
Iteration:  682 Progress:  85.25  % Time Elapsed:  1378.07 s
Iteration:  683 Progress:  85.38  % Time Elapsed:  1380.02 s
Iteration:  684 Progress:  85.50  % Time Elapsed:  1381.96 s
Iteration:  685 Progress:  85.62  % Time Elapsed:  1383.86 s
Iteration:  686 Progress:  85.75  % Time Elapsed:  1385.84 s
Iteration:  687 Progress:  85.88  % Time Elapsed:  1387.77 s
Iteration:  688 Progress:  86.00  % Time Elapsed:  1389.75 s
Iteration:  689 Progress:  86.12  % Time Elapsed:  1391.70 s
Iteration:  690 Progress:  86.25  % Time Elapsed:  1393.64 s
Iteration:  691 Progress:  86.38  % Time Elapsed:  1395.57 s
Iteration:  692 Progress:  86.50  % Time Elapsed:  1397.54 s
Iteration:  693 Progress:  86.62  % Time Elapsed:  1399.45 s
Iteration:  694 Progress:  86.75  % Time Elapsed:  1401.35 s
Iteration:  695 Progress:  86.88  % Time Elapsed:  1403.59 s
Iteration:  696 Progress:  87.00  % Time Elapsed:  1405.52 s
Iteration:  697 Progress:  87.12  % Time Elapsed:  1407.46 s
Iteration:  698 Progress:  87.25  % Time Elapsed:  1409.38 s
Iteration:  699 Progress:  87.38  % Time Elapsed:  1411.40 s
Iteration:  700 Progress:  87.50  % Time Elapsed:  1413.37 s
Iteration:  701 Progress:  87.62  % Time Elapsed:  1415.25 s
Iteration:  702 Progress:  87.75  % Time Elapsed:  1417.18 s
Iteration:  703 Progress:  87.88  % Time Elapsed:  1419.08 s
Iteration:  704 Progress:  88.00  % Time Elapsed:  1421.01 s
Iteration:  705 Progress:  88.12  % Time Elapsed:  1422.90 s
Iteration:  706 Progress:  88.25  % Time Elapsed:  1424.82 s
Iteration:  707 Progress:  88.38  % Time Elapsed:  1426.76 s
Iteration:  708 Progress:  88.50  % Time Elapsed:  1428.63 s
Iteration:  709 Progress:  88.62  % Time Elapsed:  1430.53 s
Iteration:  710 Progress:  88.75  % Time Elapsed:  1432.43 s
```

```
Iteration:  711 Progress:  88.88  % Time Elapsed:  1434.32 s
Iteration:  712 Progress:  89.00  % Time Elapsed:  1436.22 s
Iteration:  713 Progress:  89.12  % Time Elapsed:  1438.13 s
Iteration:  714 Progress:  89.25  % Time Elapsed:  1440.11 s
Iteration:  715 Progress:  89.38  % Time Elapsed:  1442.03 s
Iteration:  716 Progress:  89.50  % Time Elapsed:  1444.13 s
Iteration:  717 Progress:  89.62  % Time Elapsed:  1446.14 s
Iteration:  718 Progress:  89.75  % Time Elapsed:  1448.07 s
Iteration:  719 Progress:  89.88  % Time Elapsed:  1450.03 s
Iteration:  720 Progress:  90.00  % Time Elapsed:  1451.79 s
Epoch 17 Finished.  Time per Epoch:  80.66 s
Iteration:  721 Progress:  90.12  % Time Elapsed:  1453.73 s
Iteration:  722 Progress:  90.25  % Time Elapsed:  1455.66 s
Iteration:  723 Progress:  90.38  % Time Elapsed:  1457.50 s
Iteration:  724 Progress:  90.50  % Time Elapsed:  1459.44 s
Iteration:  725 Progress:  90.62  % Time Elapsed:  1461.34 s
Iteration:  726 Progress:  90.75  % Time Elapsed:  1463.24 s
Iteration:  727 Progress:  90.88  % Time Elapsed:  1465.12 s
Iteration:  728 Progress:  91.00  % Time Elapsed:  1467.03 s
Iteration:  729 Progress:  91.12  % Time Elapsed:  1468.98 s
Iteration:  730 Progress:  91.25  % Time Elapsed:  1470.82 s
Iteration:  731 Progress:  91.38  % Time Elapsed:  1472.79 s
Iteration:  732 Progress:  91.50  % Time Elapsed:  1474.74 s
Iteration:  733 Progress:  91.62  % Time Elapsed:  1476.66 s
Iteration:  734 Progress:  91.75  % Time Elapsed:  1478.57 s
Iteration:  735 Progress:  91.88  % Time Elapsed:  1480.54 s
Iteration:  736 Progress:  92.00  % Time Elapsed:  1482.44 s
Iteration:  737 Progress:  92.12  % Time Elapsed:  1484.40 s
Iteration:  738 Progress:  92.25  % Time Elapsed:  1486.49 s
Iteration:  739 Progress:  92.38  % Time Elapsed:  1488.37 s
Iteration:  740 Progress:  92.50  % Time Elapsed:  1490.29 s
Iteration:  741 Progress:  92.62  % Time Elapsed:  1492.15 s
Iteration:  742 Progress:  92.75  % Time Elapsed:  1494.07 s
Iteration:  743 Progress:  92.88  % Time Elapsed:  1495.96 s
Iteration:  744 Progress:  93.00  % Time Elapsed:  1497.79 s
Iteration:  745 Progress:  93.12  % Time Elapsed:  1499.75 s
Iteration:  746 Progress:  93.25  % Time Elapsed:  1501.71 s
Iteration:  747 Progress:  93.38  % Time Elapsed:  1503.66 s
Iteration:  748 Progress:  93.50  % Time Elapsed:  1505.66 s
Iteration:  749 Progress:  93.62  % Time Elapsed:  1507.57 s
Iteration:  750 Progress:  93.75  % Time Elapsed:  1509.56 s
Iteration:  751 Progress:  93.88  % Time Elapsed:  1511.47 s
Iteration:  752 Progress:  94.00  % Time Elapsed:  1513.41 s
Iteration:  753 Progress:  94.12  % Time Elapsed:  1515.39 s
Iteration:  754 Progress:  94.25  % Time Elapsed:  1517.30 s
Iteration:  755 Progress:  94.38  % Time Elapsed:  1519.20 s
Iteration:  756 Progress:  94.50  % Time Elapsed:  1521.09 s
Iteration:  757 Progress:  94.62  % Time Elapsed:  1522.98 s
Iteration:  758 Progress:  94.75  % Time Elapsed:  1524.90 s
Iteration:  759 Progress:  94.88  % Time Elapsed:  1527.01 s
Iteration:  760 Progress:  95.00  % Time Elapsed:  1528.79 s
Epoch 18 Finished.  Time per Epoch:  80.46 s
Iteration:  761 Progress:  95.12  % Time Elapsed:  1530.78 s
Iteration:  762 Progress:  95.25  % Time Elapsed:  1532.69 s
Iteration:  763 Progress:  95.38  % Time Elapsed:  1534.64 s
Iteration:  764 Progress:  95.50  % Time Elapsed:  1536.56 s
```

```
Iteration:  765 Progress:  95.62  % Time Elapsed:  1538.49 s
Iteration:  766 Progress:  95.75  % Time Elapsed:  1540.40 s
Iteration:  767 Progress:  95.88  % Time Elapsed:  1542.33 s
Iteration:  768 Progress:  96.00  % Time Elapsed:  1544.24 s
Iteration:  769 Progress:  96.12  % Time Elapsed:  1546.17 s
Iteration:  770 Progress:  96.25  % Time Elapsed:  1548.08 s
Iteration:  771 Progress:  96.38  % Time Elapsed:  1550.07 s
Iteration:  772 Progress:  96.50  % Time Elapsed:  1551.99 s
Iteration:  773 Progress:  96.62  % Time Elapsed:  1553.82 s
Iteration:  774 Progress:  96.75  % Time Elapsed:  1555.78 s
Iteration:  775 Progress:  96.88  % Time Elapsed:  1557.69 s
Iteration:  776 Progress:  97.00  % Time Elapsed:  1559.66 s
Iteration:  777 Progress:  97.12  % Time Elapsed:  1561.63 s
Iteration:  778 Progress:  97.25  % Time Elapsed:  1563.56 s
Iteration:  779 Progress:  97.38  % Time Elapsed:  1565.45 s
Iteration:  780 Progress:  97.50  % Time Elapsed:  1567.59 s
Iteration:  781 Progress:  97.62  % Time Elapsed:  1569.56 s
Iteration:  782 Progress:  97.75  % Time Elapsed:  1571.48 s
Iteration:  783 Progress:  97.88  % Time Elapsed:  1573.42 s
Iteration:  784 Progress:  98.00  % Time Elapsed:  1575.34 s
Iteration:  785 Progress:  98.12  % Time Elapsed:  1577.30 s
Iteration:  786 Progress:  98.25  % Time Elapsed:  1579.29 s
Iteration:  787 Progress:  98.38  % Time Elapsed:  1581.17 s
Iteration:  788 Progress:  98.50  % Time Elapsed:  1583.26 s
Iteration:  789 Progress:  98.62  % Time Elapsed:  1585.26 s
Iteration:  790 Progress:  98.75  % Time Elapsed:  1587.20 s
Iteration:  791 Progress:  98.88  % Time Elapsed:  1589.23 s
Iteration:  792 Progress:  99.00  % Time Elapsed:  1591.21 s
Iteration:  793 Progress:  99.12  % Time Elapsed:  1593.26 s
Iteration:  794 Progress:  99.25  % Time Elapsed:  1595.15 s
Iteration:  795 Progress:  99.38  % Time Elapsed:  1597.14 s
Iteration:  796 Progress:  99.50  % Time Elapsed:  1599.12 s
Iteration:  797 Progress:  99.62  % Time Elapsed:  1601.05 s
Iteration:  798 Progress:  99.75  % Time Elapsed:  1602.99 s
Iteration:  799 Progress:  99.88  % Time Elapsed:  1604.89 s
Iteration:  800 Progress:  100.00  % Time Elapsed:  1606.70 s
Epoch 19 Finished.  Time per Epoch:  80.33 s
```


Training Curve
Loss
0.04
0.03
0.02
0.01
0.00
0
100
200
300
400
500
600
700
800
Iterations


Training Curve
Validation Accuracy
1.0
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
800
Iterations
Training
Validation

```
Final Training Accuracy: 1.0
Final Validation Accuracy: 0.9164785553047404
Total time:   1606.70 s  Time per Epoch:  80.33 s
```

In [ ]:

```
#ALNC = alexnet.features

use_cuda = True
model = Gesture_Alex()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')

train(model,train_loader_feature,val_loader_feature,batch_size=256, num_epochs=20,
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.24  % Time Elapsed:   0.16 s
Iteration:  2 Progress:   0.48  % Time Elapsed:   0.18 s
Iteration:  3 Progress:   0.71  % Time Elapsed:   0.20 s
Iteration:  4 Progress:   0.95  % Time Elapsed:   0.22 s
Iteration:  5 Progress:   1.19  % Time Elapsed:   0.24 s
Iteration:  6 Progress:   1.43  % Time Elapsed:   0.26 s
Iteration:  7 Progress:   1.67  % Time Elapsed:   0.27 s
Iteration:  8 Progress:   1.90  % Time Elapsed:   0.29 s
Iteration:  9 Progress:   2.14  % Time Elapsed:   0.31 s
Iteration:  10 Progress:   2.38  % Time Elapsed:   0.33 s
Iteration:  11 Progress:   2.62  % Time Elapsed:   0.35 s
Iteration:  12 Progress:   2.86  % Time Elapsed:   0.37 s
Iteration:  13 Progress:   3.10  % Time Elapsed:   0.39 s
Iteration:  14 Progress:   3.33  % Time Elapsed:   0.41 s
Iteration:  15 Progress:   3.57  % Time Elapsed:   0.43 s
Iteration:  16 Progress:   3.81  % Time Elapsed:   0.44 s
Iteration:  17 Progress:   4.05  % Time Elapsed:   0.46 s
Iteration:  18 Progress:   4.29  % Time Elapsed:   0.48 s
Iteration:  19 Progress:   4.52  % Time Elapsed:   0.50 s
Iteration:  20 Progress:   4.76  % Time Elapsed:   0.52 s
Iteration:  21 Progress:   5.00  % Time Elapsed:   0.54 s
Epoch 0 Finished.  Time per Epoch:   0.54 s
Iteration:  22 Progress:   5.24  % Time Elapsed:   0.55 s
Iteration:  23 Progress:   5.48  % Time Elapsed:   0.57 s
Iteration:  24 Progress:   5.71  % Time Elapsed:   0.59 s
Iteration:  25 Progress:   5.95  % Time Elapsed:   0.61 s
Iteration:  26 Progress:   6.19  % Time Elapsed:   0.63 s
Iteration:  27 Progress:   6.43  % Time Elapsed:   0.65 s
Iteration:  28 Progress:   6.67  % Time Elapsed:   0.66 s
Iteration:  29 Progress:   6.90  % Time Elapsed:   0.68 s
Iteration:  30 Progress:   7.14  % Time Elapsed:   0.70 s
Iteration:  31 Progress:   7.38  % Time Elapsed:   0.72 s
Iteration:  32 Progress:   7.62  % Time Elapsed:   0.73 s
Iteration:  33 Progress:   7.86  % Time Elapsed:   0.76 s
Iteration:  34 Progress:   8.10  % Time Elapsed:   0.78 s
Iteration:  35 Progress:   8.33  % Time Elapsed:   0.80 s
Iteration:  36 Progress:   8.57  % Time Elapsed:   0.82 s
Iteration:  37 Progress:   8.81  % Time Elapsed:   0.84 s
Iteration:  38 Progress:   9.05  % Time Elapsed:   0.86 s
Iteration:  39 Progress:   9.29  % Time Elapsed:   0.88 s
Iteration:  40 Progress:   9.52  % Time Elapsed:   0.90 s
Iteration:  41 Progress:   9.76  % Time Elapsed:   0.92 s
Iteration:  42 Progress:  10.00  % Time Elapsed:   0.94 s
Epoch 1 Finished.  Time per Epoch:   0.47 s
Iteration:  43 Progress:  10.24  % Time Elapsed:   0.96 s
Iteration:  44 Progress:  10.48  % Time Elapsed:   0.98 s
Iteration:  45 Progress:  10.71  % Time Elapsed:   1.00 s
Iteration:  46 Progress:  10.95  % Time Elapsed:   1.01 s
Iteration:  47 Progress:  11.19  % Time Elapsed:   1.03 s
Iteration:  48 Progress:  11.43  % Time Elapsed:   1.05 s
Iteration:  49 Progress:  11.67  % Time Elapsed:   1.07 s
Iteration:  50 Progress:  11.90  % Time Elapsed:   1.09 s
Iteration:  51 Progress:  12.14  % Time Elapsed:   1.11 s
Iteration:  52 Progress:  12.38  % Time Elapsed:   1.13 s
Iteration:  53 Progress:  12.62  % Time Elapsed:   1.15 s
```

```
Iteration:  54 Progress:  12.86  % Time Elapsed:   1.17 s
Iteration:  55 Progress:  13.10  % Time Elapsed:   1.19 s
Iteration:  56 Progress:  13.33  % Time Elapsed:   1.21 s
Iteration:  57 Progress:  13.57  % Time Elapsed:   1.22 s
Iteration:  58 Progress:  13.81  % Time Elapsed:   1.24 s
Iteration:  59 Progress:  14.05  % Time Elapsed:   1.26 s
Iteration:  60 Progress:  14.29  % Time Elapsed:   1.28 s
Iteration:  61 Progress:  14.52  % Time Elapsed:   1.29 s
Iteration:  62 Progress:  14.76  % Time Elapsed:   1.31 s
Iteration:  63 Progress:  15.00  % Time Elapsed:   1.33 s
Epoch 2 Finished.  Time per Epoch:   0.44 s
Iteration:  64 Progress:  15.24  % Time Elapsed:   1.35 s
Iteration:  65 Progress:  15.48  % Time Elapsed:   1.36 s
Iteration:  66 Progress:  15.71  % Time Elapsed:   1.38 s
Iteration:  67 Progress:  15.95  % Time Elapsed:   1.40 s
Iteration:  68 Progress:  16.19  % Time Elapsed:   1.42 s
Iteration:  69 Progress:  16.43  % Time Elapsed:   1.43 s
Iteration:  70 Progress:  16.67  % Time Elapsed:   1.45 s
Iteration:  71 Progress:  16.90  % Time Elapsed:   1.47 s
Iteration:  72 Progress:  17.14  % Time Elapsed:   1.49 s
Iteration:  73 Progress:  17.38  % Time Elapsed:   1.51 s
Iteration:  74 Progress:  17.62  % Time Elapsed:   1.52 s
Iteration:  75 Progress:  17.86  % Time Elapsed:   1.54 s
Iteration:  76 Progress:  18.10  % Time Elapsed:   1.56 s
Iteration:  77 Progress:  18.33  % Time Elapsed:   1.58 s
Iteration:  78 Progress:  18.57  % Time Elapsed:   1.59 s
Iteration:  79 Progress:  18.81  % Time Elapsed:   1.61 s
Iteration:  80 Progress:  19.05  % Time Elapsed:   1.63 s
Iteration:  81 Progress:  19.29  % Time Elapsed:   1.65 s
Iteration:  82 Progress:  19.52  % Time Elapsed:   1.67 s
Iteration:  83 Progress:  19.76  % Time Elapsed:   1.69 s
Iteration:  84 Progress:  20.00  % Time Elapsed:   1.70 s
Epoch 3 Finished.  Time per Epoch:   0.43 s
Iteration:  85 Progress:  20.24  % Time Elapsed:   1.72 s
Iteration:  86 Progress:  20.48  % Time Elapsed:   1.74 s
Iteration:  87 Progress:  20.71  % Time Elapsed:   1.76 s
Iteration:  88 Progress:  20.95  % Time Elapsed:   1.78 s
Iteration:  89 Progress:  21.19  % Time Elapsed:   1.80 s
Iteration:  90 Progress:  21.43  % Time Elapsed:   1.82 s
Iteration:  91 Progress:  21.67  % Time Elapsed:   1.83 s
Iteration:  92 Progress:  21.90  % Time Elapsed:   1.85 s
Iteration:  93 Progress:  22.14  % Time Elapsed:   1.87 s
Iteration:  94 Progress:  22.38  % Time Elapsed:   1.89 s
Iteration:  95 Progress:  22.62  % Time Elapsed:   1.90 s
Iteration:  96 Progress:  22.86  % Time Elapsed:   1.92 s
Iteration:  97 Progress:  23.10  % Time Elapsed:   1.94 s
Iteration:  98 Progress:  23.33  % Time Elapsed:   1.96 s
Iteration:  99 Progress:  23.57  % Time Elapsed:   1.97 s
Iteration:  100 Progress:  23.81  % Time Elapsed:   1.99 s
Iteration:  101 Progress:  24.05  % Time Elapsed:   2.01 s
Iteration:  102 Progress:  24.29  % Time Elapsed:   2.03 s
Iteration:  103 Progress:  24.52  % Time Elapsed:   2.04 s
Iteration:  104 Progress:  24.76  % Time Elapsed:   2.06 s
Iteration:  105 Progress:  25.00  % Time Elapsed:   2.08 s
Epoch 4 Finished.  Time per Epoch:   0.42 s
Iteration:  106 Progress:  25.24  % Time Elapsed:   2.10 s
```

```
Iteration:  107 Progress:  25.48  % Time Elapsed:   2.12 s
Iteration:  108 Progress:  25.71  % Time Elapsed:   2.15 s
Iteration:  109 Progress:  25.95  % Time Elapsed:   2.18 s
Iteration:  110 Progress:  26.19  % Time Elapsed:   2.19 s
Iteration:  111 Progress:  26.43  % Time Elapsed:   2.21 s
Iteration:  112 Progress:  26.67  % Time Elapsed:   2.23 s
Iteration:  113 Progress:  26.90  % Time Elapsed:   2.25 s
Iteration:  114 Progress:  27.14  % Time Elapsed:   2.27 s
Iteration:  115 Progress:  27.38  % Time Elapsed:   2.28 s
Iteration:  116 Progress:  27.62  % Time Elapsed:   2.30 s
Iteration:  117 Progress:  27.86  % Time Elapsed:   2.32 s
Iteration:  118 Progress:  28.10  % Time Elapsed:   2.34 s
Iteration:  119 Progress:  28.33  % Time Elapsed:   2.35 s
Iteration:  120 Progress:  28.57  % Time Elapsed:   2.37 s
Iteration:  121 Progress:  28.81  % Time Elapsed:   2.39 s
Iteration:  122 Progress:  29.05  % Time Elapsed:   2.41 s
Iteration:  123 Progress:  29.29  % Time Elapsed:   2.43 s
Iteration:  124 Progress:  29.52  % Time Elapsed:   2.44 s
Iteration:  125 Progress:  29.76  % Time Elapsed:   2.46 s
Iteration:  126 Progress:  30.00  % Time Elapsed:   2.48 s
Epoch 5 Finished.  Time per Epoch:   0.41 s
Iteration:  127 Progress:  30.24  % Time Elapsed:   2.50 s
Iteration:  128 Progress:  30.48  % Time Elapsed:   2.52 s
Iteration:  129 Progress:  30.71  % Time Elapsed:   2.53 s
Iteration:  130 Progress:  30.95  % Time Elapsed:   2.55 s
Iteration:  131 Progress:  31.19  % Time Elapsed:   2.57 s
Iteration:  132 Progress:  31.43  % Time Elapsed:   2.59 s
Iteration:  133 Progress:  31.67  % Time Elapsed:   2.61 s
Iteration:  134 Progress:  31.90  % Time Elapsed:   2.62 s
Iteration:  135 Progress:  32.14  % Time Elapsed:   2.64 s
Iteration:  136 Progress:  32.38  % Time Elapsed:   2.66 s
Iteration:  137 Progress:  32.62  % Time Elapsed:   2.68 s
Iteration:  138 Progress:  32.86  % Time Elapsed:   2.70 s
Iteration:  139 Progress:  33.10  % Time Elapsed:   2.72 s
Iteration:  140 Progress:  33.33  % Time Elapsed:   2.73 s
Iteration:  141 Progress:  33.57  % Time Elapsed:   2.75 s
Iteration:  142 Progress:  33.81  % Time Elapsed:   2.77 s
Iteration:  143 Progress:  34.05  % Time Elapsed:   2.79 s
Iteration:  144 Progress:  34.29  % Time Elapsed:   2.81 s
Iteration:  145 Progress:  34.52  % Time Elapsed:   2.82 s
Iteration:  146 Progress:  34.76  % Time Elapsed:   2.84 s
Iteration:  147 Progress:  35.00  % Time Elapsed:   2.86 s
Epoch 6 Finished.  Time per Epoch:   0.41 s
Iteration:  148 Progress:  35.24  % Time Elapsed:   2.88 s
Iteration:  149 Progress:  35.48  % Time Elapsed:   2.90 s
Iteration:  150 Progress:  35.71  % Time Elapsed:   2.91 s
Iteration:  151 Progress:  35.95  % Time Elapsed:   2.93 s
Iteration:  152 Progress:  36.19  % Time Elapsed:   2.95 s
Iteration:  153 Progress:  36.43  % Time Elapsed:   2.97 s
Iteration:  154 Progress:  36.67  % Time Elapsed:   2.98 s
Iteration:  155 Progress:  36.90  % Time Elapsed:   3.00 s
Iteration:  156 Progress:  37.14  % Time Elapsed:   3.02 s
Iteration:  157 Progress:  37.38  % Time Elapsed:   3.05 s
Iteration:  158 Progress:  37.62  % Time Elapsed:   3.06 s
Iteration:  159 Progress:  37.86  % Time Elapsed:   3.08 s
Iteration:  160 Progress:  38.10  % Time Elapsed:   3.10 s
```

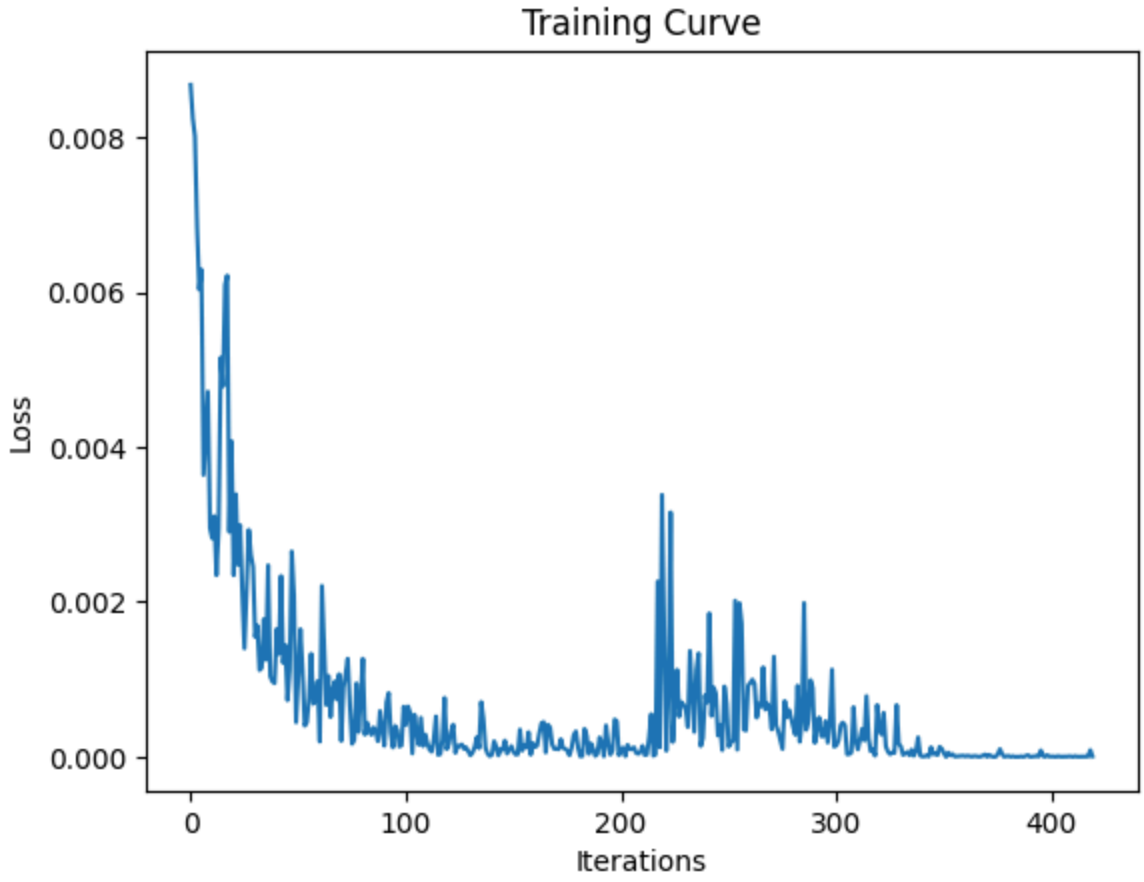
```
Iteration:  161 Progress:  38.33  % Time Elapsed:   3.12 s
Iteration:  162 Progress:  38.57  % Time Elapsed:   3.13 s
Iteration:  163 Progress:  38.81  % Time Elapsed:   3.15 s
Iteration:  164 Progress:  39.05  % Time Elapsed:   3.17 s
Iteration:  165 Progress:  39.29  % Time Elapsed:   3.20 s
Iteration:  166 Progress:  39.52  % Time Elapsed:   3.23 s
Iteration:  167 Progress:  39.76  % Time Elapsed:   3.24 s
Iteration:  168 Progress:  40.00  % Time Elapsed:   3.26 s
Epoch 7 Finished.  Time per Epoch:   0.41 s
Iteration:  169 Progress:  40.24  % Time Elapsed:   3.28 s
Iteration:  170 Progress:  40.48  % Time Elapsed:   3.30 s
Iteration:  171 Progress:  40.71  % Time Elapsed:   3.31 s
Iteration:  172 Progress:  40.95  % Time Elapsed:   3.33 s
Iteration:  173 Progress:  41.19  % Time Elapsed:   3.35 s
Iteration:  174 Progress:  41.43  % Time Elapsed:   3.37 s
Iteration:  175 Progress:  41.67  % Time Elapsed:   3.39 s
Iteration:  176 Progress:  41.90  % Time Elapsed:   3.41 s
Iteration:  177 Progress:  42.14  % Time Elapsed:   3.42 s
Iteration:  178 Progress:  42.38  % Time Elapsed:   3.44 s
Iteration:  179 Progress:  42.62  % Time Elapsed:   3.46 s
Iteration:  180 Progress:  42.86  % Time Elapsed:   3.48 s
Iteration:  181 Progress:  43.10  % Time Elapsed:   3.50 s
Iteration:  182 Progress:  43.33  % Time Elapsed:   3.51 s
Iteration:  183 Progress:  43.57  % Time Elapsed:   3.53 s
Iteration:  184 Progress:  43.81  % Time Elapsed:   3.55 s
Iteration:  185 Progress:  44.05  % Time Elapsed:   3.57 s
Iteration:  186 Progress:  44.29  % Time Elapsed:   3.59 s
Iteration:  187 Progress:  44.52  % Time Elapsed:   3.61 s
Iteration:  188 Progress:  44.76  % Time Elapsed:   3.63 s
Iteration:  189 Progress:  45.00  % Time Elapsed:   3.64 s
Epoch 8 Finished.  Time per Epoch:   0.40 s
Iteration:  190 Progress:  45.24  % Time Elapsed:   3.66 s
Iteration:  191 Progress:  45.48  % Time Elapsed:   3.68 s
Iteration:  192 Progress:  45.71  % Time Elapsed:   3.70 s
Iteration:  193 Progress:  45.95  % Time Elapsed:   3.71 s
Iteration:  194 Progress:  46.19  % Time Elapsed:   3.74 s
Iteration:  195 Progress:  46.43  % Time Elapsed:   3.77 s
Iteration:  196 Progress:  46.67  % Time Elapsed:   3.79 s
Iteration:  197 Progress:  46.90  % Time Elapsed:   3.81 s
Iteration:  198 Progress:  47.14  % Time Elapsed:   3.82 s
Iteration:  199 Progress:  47.38  % Time Elapsed:   3.85 s
Iteration:  200 Progress:  47.62  % Time Elapsed:   3.87 s
Iteration:  201 Progress:  47.86  % Time Elapsed:   3.88 s
Iteration:  202 Progress:  48.10  % Time Elapsed:   3.90 s
Iteration:  203 Progress:  48.33  % Time Elapsed:   4.00 s
Iteration:  204 Progress:  48.57  % Time Elapsed:   4.08 s
Iteration:  205 Progress:  48.81  % Time Elapsed:   4.18 s
Iteration:  206 Progress:  49.05  % Time Elapsed:   4.28 s
Iteration:  207 Progress:  49.29  % Time Elapsed:   4.31 s
Iteration:  208 Progress:  49.52  % Time Elapsed:   4.38 s
Iteration:  209 Progress:  49.76  % Time Elapsed:   4.41 s
Iteration:  210 Progress:  50.00  % Time Elapsed:   4.43 s
Epoch 9 Finished.  Time per Epoch:   0.44 s
Iteration:  211 Progress:  50.24  % Time Elapsed:   4.44 s
Iteration:  212 Progress:  50.48  % Time Elapsed:   4.46 s
Iteration:  213 Progress:  50.71  % Time Elapsed:   4.48 s
```

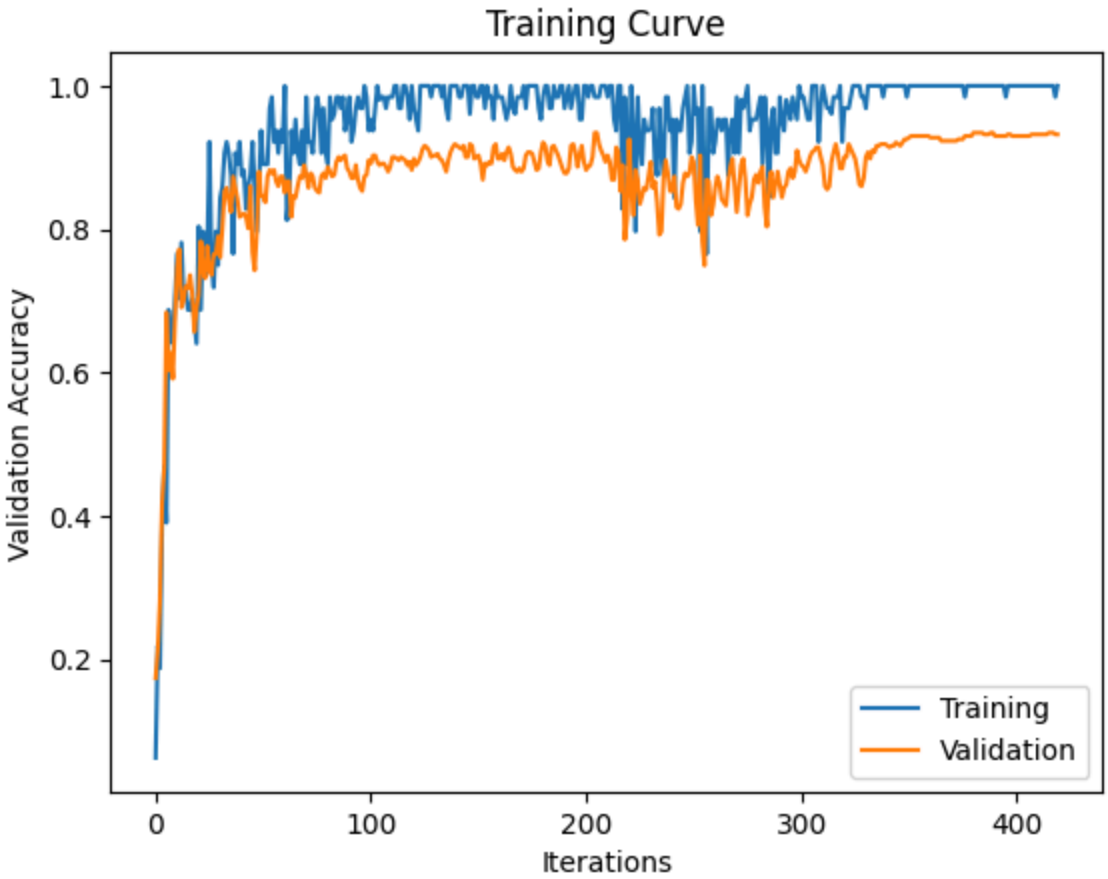
```
Iteration:  214 Progress:  50.95  % Time Elapsed:   4.50 s
Iteration:  215 Progress:  51.19  % Time Elapsed:   4.51 s
Iteration:  216 Progress:  51.43  % Time Elapsed:   4.53 s
Iteration:  217 Progress:  51.67  % Time Elapsed:   4.55 s
Iteration:  218 Progress:  51.90  % Time Elapsed:   4.57 s
Iteration:  219 Progress:  52.14  % Time Elapsed:   4.59 s
Iteration:  220 Progress:  52.38  % Time Elapsed:   4.61 s
Iteration:  221 Progress:  52.62  % Time Elapsed:   4.62 s
Iteration:  222 Progress:  52.86  % Time Elapsed:   4.64 s
Iteration:  223 Progress:  53.10  % Time Elapsed:   4.66 s
Iteration:  224 Progress:  53.33  % Time Elapsed:   4.68 s
Iteration:  225 Progress:  53.57  % Time Elapsed:   4.70 s
Iteration:  226 Progress:  53.81  % Time Elapsed:   4.72 s
Iteration:  227 Progress:  54.05  % Time Elapsed:   4.74 s
Iteration:  228 Progress:  54.29  % Time Elapsed:   4.76 s
Iteration:  229 Progress:  54.52  % Time Elapsed:   4.78 s
Iteration:  230 Progress:  54.76  % Time Elapsed:   4.79 s
Iteration:  231 Progress:  55.00  % Time Elapsed:   4.81 s
Epoch 10 Finished.  Time per Epoch:   0.44 s
Iteration:  232 Progress:  55.24  % Time Elapsed:   4.83 s
Iteration:  233 Progress:  55.48  % Time Elapsed:   4.85 s
Iteration:  234 Progress:  55.71  % Time Elapsed:   4.87 s
Iteration:  235 Progress:  55.95  % Time Elapsed:   4.89 s
Iteration:  236 Progress:  56.19  % Time Elapsed:   4.90 s
Iteration:  237 Progress:  56.43  % Time Elapsed:   4.92 s
Iteration:  238 Progress:  56.67  % Time Elapsed:   4.94 s
Iteration:  239 Progress:  56.90  % Time Elapsed:   4.96 s
Iteration:  240 Progress:  57.14  % Time Elapsed:   4.98 s
Iteration:  241 Progress:  57.38  % Time Elapsed:   4.99 s
Iteration:  242 Progress:  57.62  % Time Elapsed:   5.01 s
Iteration:  243 Progress:  57.86  % Time Elapsed:   5.03 s
Iteration:  244 Progress:  58.10  % Time Elapsed:   5.05 s
Iteration:  245 Progress:  58.33  % Time Elapsed:   5.07 s
Iteration:  246 Progress:  58.57  % Time Elapsed:   5.08 s
Iteration:  247 Progress:  58.81  % Time Elapsed:   5.10 s
Iteration:  248 Progress:  59.05  % Time Elapsed:   5.12 s
Iteration:  249 Progress:  59.29  % Time Elapsed:   5.14 s
Iteration:  250 Progress:  59.52  % Time Elapsed:   5.16 s
Iteration:  251 Progress:  59.76  % Time Elapsed:   5.18 s
Iteration:  252 Progress:  60.00  % Time Elapsed:   5.19 s
Epoch 11 Finished.  Time per Epoch:   0.43 s
Iteration:  253 Progress:  60.24  % Time Elapsed:   5.21 s
Iteration:  254 Progress:  60.48  % Time Elapsed:   5.23 s
Iteration:  255 Progress:  60.71  % Time Elapsed:   5.25 s
Iteration:  256 Progress:  60.95  % Time Elapsed:   5.26 s
Iteration:  257 Progress:  61.19  % Time Elapsed:   5.28 s
Iteration:  258 Progress:  61.43  % Time Elapsed:   5.31 s
Iteration:  259 Progress:  61.67  % Time Elapsed:   5.33 s
Iteration:  260 Progress:  61.90  % Time Elapsed:   5.35 s
Iteration:  261 Progress:  62.14  % Time Elapsed:   5.37 s
Iteration:  262 Progress:  62.38  % Time Elapsed:   5.39 s
Iteration:  263 Progress:  62.62  % Time Elapsed:   5.40 s
Iteration:  264 Progress:  62.86  % Time Elapsed:   5.42 s
Iteration:  265 Progress:  63.10  % Time Elapsed:   5.44 s
Iteration:  266 Progress:  63.33  % Time Elapsed:   5.46 s
Iteration:  267 Progress:  63.57  % Time Elapsed:   5.47 s
```

```
Iteration:  268 Progress:  63.81  % Time Elapsed:   5.49 s
Iteration:  269 Progress:  64.05  % Time Elapsed:   5.51 s
Iteration:  270 Progress:  64.29  % Time Elapsed:   5.52 s
Iteration:  271 Progress:  64.52  % Time Elapsed:   5.54 s
Iteration:  272 Progress:  64.76  % Time Elapsed:   5.56 s
Iteration:  273 Progress:  65.00  % Time Elapsed:   5.58 s
Epoch 12 Finished.  Time per Epoch:   0.43 s
Iteration:  274 Progress:  65.24  % Time Elapsed:   5.60 s
Iteration:  275 Progress:  65.48  % Time Elapsed:   5.62 s
Iteration:  276 Progress:  65.71  % Time Elapsed:   5.63 s
Iteration:  277 Progress:  65.95  % Time Elapsed:   5.65 s
Iteration:  278 Progress:  66.19  % Time Elapsed:   5.67 s
Iteration:  279 Progress:  66.43  % Time Elapsed:   5.69 s
Iteration:  280 Progress:  66.67  % Time Elapsed:   5.71 s
Iteration:  281 Progress:  66.90  % Time Elapsed:   5.72 s
Iteration:  282 Progress:  67.14  % Time Elapsed:   5.74 s
Iteration:  283 Progress:  67.38  % Time Elapsed:   5.76 s
Iteration:  284 Progress:  67.62  % Time Elapsed:   5.78 s
Iteration:  285 Progress:  67.86  % Time Elapsed:   5.80 s
Iteration:  286 Progress:  68.10  % Time Elapsed:   5.82 s
Iteration:  287 Progress:  68.33  % Time Elapsed:   5.84 s
Iteration:  288 Progress:  68.57  % Time Elapsed:   5.86 s
Iteration:  289 Progress:  68.81  % Time Elapsed:   5.87 s
Iteration:  290 Progress:  69.05  % Time Elapsed:   5.89 s
Iteration:  291 Progress:  69.29  % Time Elapsed:   5.91 s
Iteration:  292 Progress:  69.52  % Time Elapsed:   5.92 s
Iteration:  293 Progress:  69.76  % Time Elapsed:   5.94 s
Iteration:  294 Progress:  70.00  % Time Elapsed:   5.96 s
Epoch 13 Finished.  Time per Epoch:   0.43 s
Iteration:  295 Progress:  70.24  % Time Elapsed:   5.98 s
Iteration:  296 Progress:  70.48  % Time Elapsed:   6.00 s
Iteration:  297 Progress:  70.71  % Time Elapsed:   6.01 s
Iteration:  298 Progress:  70.95  % Time Elapsed:   6.03 s
Iteration:  299 Progress:  71.19  % Time Elapsed:   6.05 s
Iteration:  300 Progress:  71.43  % Time Elapsed:   6.06 s
Iteration:  301 Progress:  71.67  % Time Elapsed:   6.08 s
Iteration:  302 Progress:  71.90  % Time Elapsed:   6.10 s
Iteration:  303 Progress:  72.14  % Time Elapsed:   6.12 s
Iteration:  304 Progress:  72.38  % Time Elapsed:   6.13 s
Iteration:  305 Progress:  72.62  % Time Elapsed:   6.15 s
Iteration:  306 Progress:  72.86  % Time Elapsed:   6.17 s
Iteration:  307 Progress:  73.10  % Time Elapsed:   6.18 s
Iteration:  308 Progress:  73.33  % Time Elapsed:   6.20 s
Iteration:  309 Progress:  73.57  % Time Elapsed:   6.22 s
Iteration:  310 Progress:  73.81  % Time Elapsed:   6.23 s
Iteration:  311 Progress:  74.05  % Time Elapsed:   6.25 s
Iteration:  312 Progress:  74.29  % Time Elapsed:   6.27 s
Iteration:  313 Progress:  74.52  % Time Elapsed:   6.28 s
Iteration:  314 Progress:  74.76  % Time Elapsed:   6.30 s
Iteration:  315 Progress:  75.00  % Time Elapsed:   6.32 s
Epoch 14 Finished.  Time per Epoch:   0.42 s
Iteration:  316 Progress:  75.24  % Time Elapsed:   6.34 s
Iteration:  317 Progress:  75.48  % Time Elapsed:   6.37 s
Iteration:  318 Progress:  75.71  % Time Elapsed:   6.39 s
Iteration:  319 Progress:  75.95  % Time Elapsed:   6.41 s
Iteration:  320 Progress:  76.19  % Time Elapsed:   6.43 s
```

```
Iteration:  321 Progress:  76.43  % Time Elapsed:   6.44 s
Iteration:  322 Progress:  76.67  % Time Elapsed:   6.46 s
Iteration:  323 Progress:  76.90  % Time Elapsed:   6.48 s
Iteration:  324 Progress:  77.14  % Time Elapsed:   6.49 s
Iteration:  325 Progress:  77.38  % Time Elapsed:   6.51 s
Iteration:  326 Progress:  77.62  % Time Elapsed:   6.53 s
Iteration:  327 Progress:  77.86  % Time Elapsed:   6.55 s
Iteration:  328 Progress:  78.10  % Time Elapsed:   6.56 s
Iteration:  329 Progress:  78.33  % Time Elapsed:   6.79 s
Iteration:  330 Progress:  78.57  % Time Elapsed:   6.81 s
Iteration:  331 Progress:  78.81  % Time Elapsed:   6.82 s
Iteration:  332 Progress:  79.05  % Time Elapsed:   6.84 s
Iteration:  333 Progress:  79.29  % Time Elapsed:   6.86 s
Iteration:  334 Progress:  79.52  % Time Elapsed:   6.88 s
Iteration:  335 Progress:  79.76  % Time Elapsed:   6.89 s
Iteration:  336 Progress:  80.00  % Time Elapsed:   6.91 s
Epoch 15 Finished.  Time per Epoch:   0.43 s
Iteration:  337 Progress:  80.24  % Time Elapsed:   6.93 s
Iteration:  338 Progress:  80.48  % Time Elapsed:   6.94 s
Iteration:  339 Progress:  80.71  % Time Elapsed:   6.96 s
Iteration:  340 Progress:  80.95  % Time Elapsed:   6.98 s
Iteration:  341 Progress:  81.19  % Time Elapsed:   7.00 s
Iteration:  342 Progress:  81.43  % Time Elapsed:   7.02 s
Iteration:  343 Progress:  81.67  % Time Elapsed:   7.03 s
Iteration:  344 Progress:  81.90  % Time Elapsed:   7.05 s
Iteration:  345 Progress:  82.14  % Time Elapsed:   7.07 s
Iteration:  346 Progress:  82.38  % Time Elapsed:   7.09 s
Iteration:  347 Progress:  82.62  % Time Elapsed:   7.10 s
Iteration:  348 Progress:  82.86  % Time Elapsed:   7.12 s
Iteration:  349 Progress:  83.10  % Time Elapsed:   7.14 s
Iteration:  350 Progress:  83.33  % Time Elapsed:   7.16 s
Iteration:  351 Progress:  83.57  % Time Elapsed:   7.17 s
Iteration:  352 Progress:  83.81  % Time Elapsed:   7.19 s
Iteration:  353 Progress:  84.05  % Time Elapsed:   7.21 s
Iteration:  354 Progress:  84.29  % Time Elapsed:   7.23 s
Iteration:  355 Progress:  84.52  % Time Elapsed:   7.25 s
Iteration:  356 Progress:  84.76  % Time Elapsed:   7.26 s
Iteration:  357 Progress:  85.00  % Time Elapsed:   7.28 s
Epoch 16 Finished.  Time per Epoch:   0.43 s
Iteration:  358 Progress:  85.24  % Time Elapsed:   7.30 s
Iteration:  359 Progress:  85.48  % Time Elapsed:   7.31 s
Iteration:  360 Progress:  85.71  % Time Elapsed:   7.33 s
Iteration:  361 Progress:  85.95  % Time Elapsed:   7.35 s
Iteration:  362 Progress:  86.19  % Time Elapsed:   7.37 s
Iteration:  363 Progress:  86.43  % Time Elapsed:   7.40 s
Iteration:  364 Progress:  86.67  % Time Elapsed:   7.42 s
Iteration:  365 Progress:  86.90  % Time Elapsed:   7.45 s
Iteration:  366 Progress:  87.14  % Time Elapsed:   7.47 s
Iteration:  367 Progress:  87.38  % Time Elapsed:   7.50 s
Iteration:  368 Progress:  87.62  % Time Elapsed:   7.53 s
Iteration:  369 Progress:  87.86  % Time Elapsed:   7.55 s
Iteration:  370 Progress:  88.10  % Time Elapsed:   7.58 s
Iteration:  371 Progress:  88.33  % Time Elapsed:   7.60 s
Iteration:  372 Progress:  88.57  % Time Elapsed:   7.63 s
Iteration:  373 Progress:  88.81  % Time Elapsed:   7.66 s
Iteration:  374 Progress:  89.05  % Time Elapsed:   7.69 s
```

```
Iteration:  375 Progress:  89.29  % Time Elapsed:   7.71 s
Iteration:  376 Progress:  89.52  % Time Elapsed:   7.74 s
Iteration:  377 Progress:  89.76  % Time Elapsed:   7.77 s
Iteration:  378 Progress:  90.00  % Time Elapsed:   7.80 s
Epoch 17 Finished.  Time per Epoch:   0.43 s
Iteration:  379 Progress:  90.24  % Time Elapsed:   7.82 s
Iteration:  380 Progress:  90.48  % Time Elapsed:   7.85 s
Iteration:  381 Progress:  90.71  % Time Elapsed:   7.88 s
Iteration:  382 Progress:  90.95  % Time Elapsed:   7.90 s
Iteration:  383 Progress:  91.19  % Time Elapsed:   7.92 s
Iteration:  384 Progress:  91.43  % Time Elapsed:   7.95 s
Iteration:  385 Progress:  91.67  % Time Elapsed:   7.97 s
Iteration:  386 Progress:  91.90  % Time Elapsed:   8.00 s
Iteration:  387 Progress:  92.14  % Time Elapsed:   8.02 s
Iteration:  388 Progress:  92.38  % Time Elapsed:   8.05 s
Iteration:  389 Progress:  92.62  % Time Elapsed:   8.08 s
Iteration:  390 Progress:  92.86  % Time Elapsed:   8.11 s
Iteration:  391 Progress:  93.10  % Time Elapsed:   8.13 s
Iteration:  392 Progress:  93.33  % Time Elapsed:   8.16 s
Iteration:  393 Progress:  93.57  % Time Elapsed:   8.18 s
Iteration:  394 Progress:  93.81  % Time Elapsed:   8.20 s
Iteration:  395 Progress:  94.05  % Time Elapsed:   8.23 s
Iteration:  396 Progress:  94.29  % Time Elapsed:   8.25 s
Iteration:  397 Progress:  94.52  % Time Elapsed:   8.28 s
Iteration:  398 Progress:  94.76  % Time Elapsed:   8.31 s
Iteration:  399 Progress:  95.00  % Time Elapsed:   8.33 s
Epoch 18 Finished.  Time per Epoch:   0.44 s
Iteration:  400 Progress:  95.24  % Time Elapsed:   8.36 s
Iteration:  401 Progress:  95.48  % Time Elapsed:   8.39 s
Iteration:  402 Progress:  95.71  % Time Elapsed:   8.42 s
Iteration:  403 Progress:  95.95  % Time Elapsed:   8.45 s
Iteration:  404 Progress:  96.19  % Time Elapsed:   8.48 s
Iteration:  405 Progress:  96.43  % Time Elapsed:   8.51 s
Iteration:  406 Progress:  96.67  % Time Elapsed:   8.53 s
Iteration:  407 Progress:  96.90  % Time Elapsed:   8.56 s
Iteration:  408 Progress:  97.14  % Time Elapsed:   8.59 s
Iteration:  409 Progress:  97.38  % Time Elapsed:   8.61 s
Iteration:  410 Progress:  97.62  % Time Elapsed:   8.63 s
Iteration:  411 Progress:  97.86  % Time Elapsed:   8.66 s
Iteration:  412 Progress:  98.10  % Time Elapsed:   8.68 s
Iteration:  413 Progress:  98.33  % Time Elapsed:   8.71 s
Iteration:  414 Progress:  98.57  % Time Elapsed:   8.74 s
Iteration:  415 Progress:  98.81  % Time Elapsed:   8.77 s
Iteration:  416 Progress:  99.05  % Time Elapsed:   8.81 s
Iteration:  417 Progress:  99.29  % Time Elapsed:   8.84 s
Iteration:  418 Progress:  99.52  % Time Elapsed:   8.87 s
Iteration:  419 Progress:  99.76  % Time Elapsed:   8.90 s
Iteration:  420 Progress:  100.00  % Time Elapsed:   8.93 s
Epoch 19 Finished.  Time per Epoch:   0.45 s
```


Training Curve
Loss
0.008
0.006
0.004
0.002
0.000
0
100
200
300
400
Iterations


Training Curve
Validation Accuracy
1.0
0.8
0.6
0.4
0.2
0
100
200
300
400
Iterations
Training
Validation

```
Final Training Accuracy: 0.9992486851990984
Final Validation Accuracy: 0.9322799097065463
Total time:    8.93 s  Time per Epoch:   0.45 s
```

In [ ]:

```python
#ALNC = alexnet.features

use_cuda = True
model = Gesture_Alex()

if use_cuda and torch.cuda.is_available():
  model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')

#proper model
train(model,train_loader_feature,val_loader_feature,batch_size=256, num_epochs=20,
```

```
CUDA is not available.  Training on CPU ...
Iteration:  1 Progress:   0.24  % Time Elapsed:   0.02 s
Iteration:  2 Progress:   0.48  % Time Elapsed:   0.04 s
Iteration:  3 Progress:   0.71  % Time Elapsed:   0.06 s
Iteration:  4 Progress:   0.95  % Time Elapsed:   0.08 s
Iteration:  5 Progress:   1.19  % Time Elapsed:   0.10 s
Iteration:  6 Progress:   1.43  % Time Elapsed:   0.12 s
Iteration:  7 Progress:   1.67  % Time Elapsed:   0.14 s
Iteration:  8 Progress:   1.90  % Time Elapsed:   0.17 s
Iteration:  9 Progress:   2.14  % Time Elapsed:   0.19 s
Iteration:  10 Progress:   2.38  % Time Elapsed:   0.21 s
Iteration:  11 Progress:   2.62  % Time Elapsed:   0.23 s
Iteration:  12 Progress:   2.86  % Time Elapsed:   0.25 s
Iteration:  13 Progress:   3.10  % Time Elapsed:   0.27 s
Iteration:  14 Progress:   3.33  % Time Elapsed:   0.29 s
Iteration:  15 Progress:   3.57  % Time Elapsed:   0.31 s
Iteration:  16 Progress:   3.81  % Time Elapsed:   0.33 s
Iteration:  17 Progress:   4.05  % Time Elapsed:   0.35 s
Iteration:  18 Progress:   4.29  % Time Elapsed:   0.37 s
Iteration:  19 Progress:   4.52  % Time Elapsed:   0.39 s
Iteration:  20 Progress:   4.76  % Time Elapsed:   0.41 s
Iteration:  21 Progress:   5.00  % Time Elapsed:   0.43 s
Epoch 0 Finished.  Time per Epoch:   0.43 s
Iteration:  22 Progress:   5.24  % Time Elapsed:   0.45 s
Iteration:  23 Progress:   5.48  % Time Elapsed:   0.47 s
Iteration:  24 Progress:   5.71  % Time Elapsed:   0.49 s
Iteration:  25 Progress:   5.95  % Time Elapsed:   0.51 s
Iteration:  26 Progress:   6.19  % Time Elapsed:   0.53 s
Iteration:  27 Progress:   6.43  % Time Elapsed:   0.55 s
Iteration:  28 Progress:   6.67  % Time Elapsed:   0.57 s
Iteration:  29 Progress:   6.90  % Time Elapsed:   0.59 s
Iteration:  30 Progress:   7.14  % Time Elapsed:   0.61 s
Iteration:  31 Progress:   7.38  % Time Elapsed:   0.63 s
Iteration:  32 Progress:   7.62  % Time Elapsed:   0.65 s
Iteration:  33 Progress:   7.86  % Time Elapsed:   0.67 s
Iteration:  34 Progress:   8.10  % Time Elapsed:   0.69 s
Iteration:  35 Progress:   8.33  % Time Elapsed:   0.71 s
Iteration:  36 Progress:   8.57  % Time Elapsed:   0.72 s
Iteration:  37 Progress:   8.81  % Time Elapsed:   0.74 s
Iteration:  38 Progress:   9.05  % Time Elapsed:   0.76 s
Iteration:  39 Progress:   9.29  % Time Elapsed:   0.78 s
Iteration:  40 Progress:   9.52  % Time Elapsed:   0.80 s
Iteration:  41 Progress:   9.76  % Time Elapsed:   0.82 s
Iteration:  42 Progress:  10.00  % Time Elapsed:   0.84 s
Epoch 1 Finished.  Time per Epoch:   0.42 s
Iteration:  43 Progress:  10.24  % Time Elapsed:   0.86 s
Iteration:  44 Progress:  10.48  % Time Elapsed:   0.88 s
Iteration:  45 Progress:  10.71  % Time Elapsed:   0.90 s
Iteration:  46 Progress:  10.95  % Time Elapsed:   0.92 s
Iteration:  47 Progress:  11.19  % Time Elapsed:   0.94 s
Iteration:  48 Progress:  11.43  % Time Elapsed:   0.96 s
Iteration:  49 Progress:  11.67  % Time Elapsed:   0.98 s
Iteration:  50 Progress:  11.90  % Time Elapsed:   1.00 s
Iteration:  51 Progress:  12.14  % Time Elapsed:   1.02 s
Iteration:  52 Progress:  12.38  % Time Elapsed:   1.04 s
Iteration:  53 Progress:  12.62  % Time Elapsed:   1.06 s
```

```
Iteration:  54 Progress:  12.86  % Time Elapsed:   1.08 s
Iteration:  55 Progress:  13.10  % Time Elapsed:   1.11 s
Iteration:  56 Progress:  13.33  % Time Elapsed:   1.13 s
Iteration:  57 Progress:  13.57  % Time Elapsed:   1.15 s
Iteration:  58 Progress:  13.81  % Time Elapsed:   1.17 s
Iteration:  59 Progress:  14.05  % Time Elapsed:   1.19 s
Iteration:  60 Progress:  14.29  % Time Elapsed:   1.22 s
Iteration:  61 Progress:  14.52  % Time Elapsed:   1.24 s
Iteration:  62 Progress:  14.76  % Time Elapsed:   1.26 s
Iteration:  63 Progress:  15.00  % Time Elapsed:   1.28 s
Epoch 2 Finished.  Time per Epoch:   0.43 s
Iteration:  64 Progress:  15.24  % Time Elapsed:   1.30 s
Iteration:  65 Progress:  15.48  % Time Elapsed:   1.32 s
Iteration:  66 Progress:  15.71  % Time Elapsed:   1.34 s
Iteration:  67 Progress:  15.95  % Time Elapsed:   1.36 s
Iteration:  68 Progress:  16.19  % Time Elapsed:   1.38 s
Iteration:  69 Progress:  16.43  % Time Elapsed:   1.40 s
Iteration:  70 Progress:  16.67  % Time Elapsed:   1.42 s
Iteration:  71 Progress:  16.90  % Time Elapsed:   1.44 s
Iteration:  72 Progress:  17.14  % Time Elapsed:   1.46 s
Iteration:  73 Progress:  17.38  % Time Elapsed:   1.48 s
Iteration:  74 Progress:  17.62  % Time Elapsed:   1.50 s
Iteration:  75 Progress:  17.86  % Time Elapsed:   1.52 s
Iteration:  76 Progress:  18.10  % Time Elapsed:   1.54 s
Iteration:  77 Progress:  18.33  % Time Elapsed:   1.56 s
Iteration:  78 Progress:  18.57  % Time Elapsed:   1.58 s
Iteration:  79 Progress:  18.81  % Time Elapsed:   1.60 s
Iteration:  80 Progress:  19.05  % Time Elapsed:   1.62 s
Iteration:  81 Progress:  19.29  % Time Elapsed:   1.64 s
Iteration:  82 Progress:  19.52  % Time Elapsed:   1.66 s
Iteration:  83 Progress:  19.76  % Time Elapsed:   1.68 s
Iteration:  84 Progress:  20.00  % Time Elapsed:   1.70 s
Epoch 3 Finished.  Time per Epoch:   0.43 s
Iteration:  85 Progress:  20.24  % Time Elapsed:   1.72 s
Iteration:  86 Progress:  20.48  % Time Elapsed:   1.74 s
Iteration:  87 Progress:  20.71  % Time Elapsed:   1.76 s
Iteration:  88 Progress:  20.95  % Time Elapsed:   1.78 s
Iteration:  89 Progress:  21.19  % Time Elapsed:   1.80 s
Iteration:  90 Progress:  21.43  % Time Elapsed:   1.82 s
Iteration:  91 Progress:  21.67  % Time Elapsed:   1.84 s
Iteration:  92 Progress:  21.90  % Time Elapsed:   1.86 s
Iteration:  93 Progress:  22.14  % Time Elapsed:   1.88 s
Iteration:  94 Progress:  22.38  % Time Elapsed:   1.90 s
Iteration:  95 Progress:  22.62  % Time Elapsed:   1.92 s
Iteration:  96 Progress:  22.86  % Time Elapsed:   1.95 s
Iteration:  97 Progress:  23.10  % Time Elapsed:   1.97 s
Iteration:  98 Progress:  23.33  % Time Elapsed:   1.99 s
Iteration:  99 Progress:  23.57  % Time Elapsed:   2.01 s
Iteration:  100 Progress:  23.81  % Time Elapsed:   2.03 s
Iteration:  101 Progress:  24.05  % Time Elapsed:   2.05 s
Iteration:  102 Progress:  24.29  % Time Elapsed:   2.07 s
Iteration:  103 Progress:  24.52  % Time Elapsed:   2.09 s
Iteration:  104 Progress:  24.76  % Time Elapsed:   2.11 s
Iteration:  105 Progress:  25.00  % Time Elapsed:   2.13 s
Epoch 4 Finished.  Time per Epoch:   0.43 s
Iteration:  106 Progress:  25.24  % Time Elapsed:   2.14 s
```

```
Iteration:  107 Progress:  25.48  % Time Elapsed:   2.16 s
Iteration:  108 Progress:  25.71  % Time Elapsed:   2.18 s
Iteration:  109 Progress:  25.95  % Time Elapsed:   2.20 s
Iteration:  110 Progress:  26.19  % Time Elapsed:   2.22 s
Iteration:  111 Progress:  26.43  % Time Elapsed:   2.25 s
Iteration:  112 Progress:  26.67  % Time Elapsed:   2.27 s
Iteration:  113 Progress:  26.90  % Time Elapsed:   2.30 s
Iteration:  114 Progress:  27.14  % Time Elapsed:   2.32 s
Iteration:  115 Progress:  27.38  % Time Elapsed:   2.34 s
Iteration:  116 Progress:  27.62  % Time Elapsed:   2.36 s
Iteration:  117 Progress:  27.86  % Time Elapsed:   2.38 s
Iteration:  118 Progress:  28.10  % Time Elapsed:   2.40 s
Iteration:  119 Progress:  28.33  % Time Elapsed:   2.42 s
Iteration:  120 Progress:  28.57  % Time Elapsed:   2.44 s
Iteration:  121 Progress:  28.81  % Time Elapsed:   2.46 s
Iteration:  122 Progress:  29.05  % Time Elapsed:   2.48 s
Iteration:  123 Progress:  29.29  % Time Elapsed:   2.50 s
Iteration:  124 Progress:  29.52  % Time Elapsed:   2.52 s
Iteration:  125 Progress:  29.76  % Time Elapsed:   2.54 s
Iteration:  126 Progress:  30.00  % Time Elapsed:   2.56 s
Epoch 5 Finished.  Time per Epoch:   0.43 s
Iteration:  127 Progress:  30.24  % Time Elapsed:   2.58 s
Iteration:  128 Progress:  30.48  % Time Elapsed:   2.60 s
Iteration:  129 Progress:  30.71  % Time Elapsed:   2.62 s
Iteration:  130 Progress:  30.95  % Time Elapsed:   2.64 s
Iteration:  131 Progress:  31.19  % Time Elapsed:   2.66 s
Iteration:  132 Progress:  31.43  % Time Elapsed:   2.68 s
Iteration:  133 Progress:  31.67  % Time Elapsed:   2.70 s
Iteration:  134 Progress:  31.90  % Time Elapsed:   2.72 s
Iteration:  135 Progress:  32.14  % Time Elapsed:   2.74 s
Iteration:  136 Progress:  32.38  % Time Elapsed:   2.76 s
Iteration:  137 Progress:  32.62  % Time Elapsed:   2.78 s
Iteration:  138 Progress:  32.86  % Time Elapsed:   2.80 s
Iteration:  139 Progress:  33.10  % Time Elapsed:   2.82 s
Iteration:  140 Progress:  33.33  % Time Elapsed:   2.84 s
Iteration:  141 Progress:  33.57  % Time Elapsed:   2.86 s
Iteration:  142 Progress:  33.81  % Time Elapsed:   2.88 s
Iteration:  143 Progress:  34.05  % Time Elapsed:   2.90 s
Iteration:  144 Progress:  34.29  % Time Elapsed:   2.92 s
Iteration:  145 Progress:  34.52  % Time Elapsed:   2.94 s
Iteration:  146 Progress:  34.76  % Time Elapsed:   2.96 s
Iteration:  147 Progress:  35.00  % Time Elapsed:   2.97 s
Epoch 6 Finished.  Time per Epoch:   0.42 s
Iteration:  148 Progress:  35.24  % Time Elapsed:   2.99 s
Iteration:  149 Progress:  35.48  % Time Elapsed:   3.01 s
Iteration:  150 Progress:  35.71  % Time Elapsed:   3.04 s
Iteration:  151 Progress:  35.95  % Time Elapsed:   3.06 s
Iteration:  152 Progress:  36.19  % Time Elapsed:   3.07 s
Iteration:  153 Progress:  36.43  % Time Elapsed:   3.09 s
Iteration:  154 Progress:  36.67  % Time Elapsed:   3.11 s
Iteration:  155 Progress:  36.90  % Time Elapsed:   3.13 s
Iteration:  156 Progress:  37.14  % Time Elapsed:   3.15 s
Iteration:  157 Progress:  37.38  % Time Elapsed:   3.17 s
Iteration:  158 Progress:  37.62  % Time Elapsed:   3.19 s
Iteration:  159 Progress:  37.86  % Time Elapsed:   3.21 s
Iteration:  160 Progress:  38.10  % Time Elapsed:   3.23 s
```

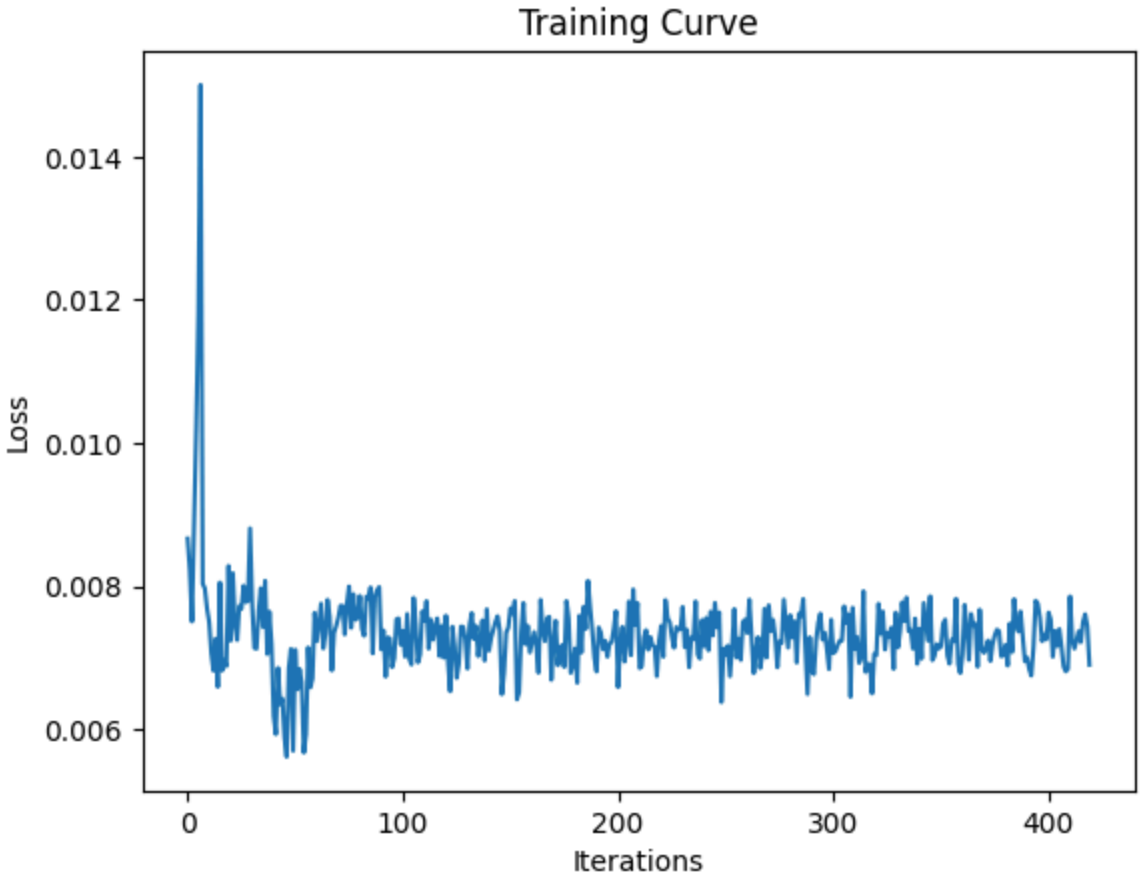
```
Iteration:  161 Progress:  38.33  % Time Elapsed:   3.25 s
Iteration:  162 Progress:  38.57  % Time Elapsed:   3.27 s
Iteration:  163 Progress:  38.81  % Time Elapsed:   3.30 s
Iteration:  164 Progress:  39.05  % Time Elapsed:   3.33 s
Iteration:  165 Progress:  39.29  % Time Elapsed:   3.35 s
Iteration:  166 Progress:  39.52  % Time Elapsed:   3.37 s
Iteration:  167 Progress:  39.76  % Time Elapsed:   3.39 s
Iteration:  168 Progress:  40.00  % Time Elapsed:   3.41 s
Epoch 7 Finished.  Time per Epoch:   0.43 s
Iteration:  169 Progress:  40.24  % Time Elapsed:   3.42 s
Iteration:  170 Progress:  40.48  % Time Elapsed:   3.44 s
Iteration:  171 Progress:  40.71  % Time Elapsed:   3.47 s
Iteration:  172 Progress:  40.95  % Time Elapsed:   3.49 s
Iteration:  173 Progress:  41.19  % Time Elapsed:   3.50 s
Iteration:  174 Progress:  41.43  % Time Elapsed:   3.52 s
Iteration:  175 Progress:  41.67  % Time Elapsed:   3.54 s
Iteration:  176 Progress:  41.90  % Time Elapsed:   3.56 s
Iteration:  177 Progress:  42.14  % Time Elapsed:   3.58 s
Iteration:  178 Progress:  42.38  % Time Elapsed:   3.60 s
Iteration:  179 Progress:  42.62  % Time Elapsed:   3.62 s
Iteration:  180 Progress:  42.86  % Time Elapsed:   3.64 s
Iteration:  181 Progress:  43.10  % Time Elapsed:   3.66 s
Iteration:  182 Progress:  43.33  % Time Elapsed:   3.68 s
Iteration:  183 Progress:  43.57  % Time Elapsed:   3.70 s
Iteration:  184 Progress:  43.81  % Time Elapsed:   3.72 s
Iteration:  185 Progress:  44.05  % Time Elapsed:   3.74 s
Iteration:  186 Progress:  44.29  % Time Elapsed:   3.76 s
Iteration:  187 Progress:  44.52  % Time Elapsed:   3.78 s
Iteration:  188 Progress:  44.76  % Time Elapsed:   3.80 s
Iteration:  189 Progress:  45.00  % Time Elapsed:   3.81 s
Epoch 8 Finished.  Time per Epoch:   0.42 s
Iteration:  190 Progress:  45.24  % Time Elapsed:   3.83 s
Iteration:  191 Progress:  45.48  % Time Elapsed:   3.85 s
Iteration:  192 Progress:  45.71  % Time Elapsed:   3.87 s
Iteration:  193 Progress:  45.95  % Time Elapsed:   3.89 s
Iteration:  194 Progress:  46.19  % Time Elapsed:   3.91 s
Iteration:  195 Progress:  46.43  % Time Elapsed:   3.93 s
Iteration:  196 Progress:  46.67  % Time Elapsed:   3.95 s
Iteration:  197 Progress:  46.90  % Time Elapsed:   3.97 s
Iteration:  198 Progress:  47.14  % Time Elapsed:   3.99 s
Iteration:  199 Progress:  47.38  % Time Elapsed:   4.01 s
Iteration:  200 Progress:  47.62  % Time Elapsed:   4.03 s
Iteration:  201 Progress:  47.86  % Time Elapsed:   4.05 s
Iteration:  202 Progress:  48.10  % Time Elapsed:   4.07 s
Iteration:  203 Progress:  48.33  % Time Elapsed:   4.09 s
Iteration:  204 Progress:  48.57  % Time Elapsed:   4.11 s
Iteration:  205 Progress:  48.81  % Time Elapsed:   4.13 s
Iteration:  206 Progress:  49.05  % Time Elapsed:   4.15 s
Iteration:  207 Progress:  49.29  % Time Elapsed:   4.17 s
Iteration:  208 Progress:  49.52  % Time Elapsed:   4.19 s
Iteration:  209 Progress:  49.76  % Time Elapsed:   4.21 s
Iteration:  210 Progress:  50.00  % Time Elapsed:   4.23 s
Epoch 9 Finished.  Time per Epoch:   0.42 s
Iteration:  211 Progress:  50.24  % Time Elapsed:   4.25 s
Iteration:  212 Progress:  50.48  % Time Elapsed:   4.27 s
Iteration:  213 Progress:  50.71  % Time Elapsed:   4.29 s
```

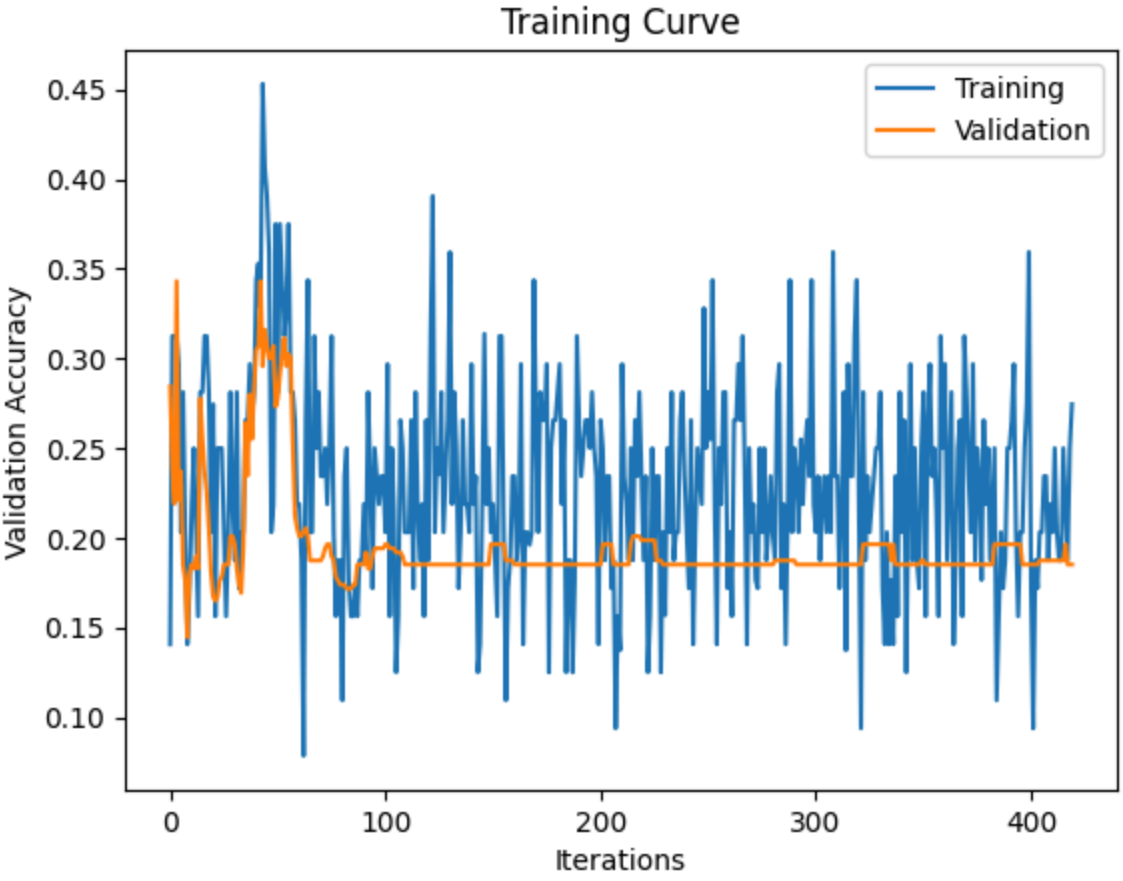
```
Iteration:  214 Progress:  50.95  % Time Elapsed:   4.32 s
Iteration:  215 Progress:  51.19  % Time Elapsed:   4.35 s
Iteration:  216 Progress:  51.43  % Time Elapsed:   4.37 s
Iteration:  217 Progress:  51.67  % Time Elapsed:   4.39 s
Iteration:  218 Progress:  51.90  % Time Elapsed:   4.41 s
Iteration:  219 Progress:  52.14  % Time Elapsed:   4.43 s
Iteration:  220 Progress:  52.38  % Time Elapsed:   4.45 s
Iteration:  221 Progress:  52.62  % Time Elapsed:   4.47 s
Iteration:  222 Progress:  52.86  % Time Elapsed:   4.49 s
Iteration:  223 Progress:  53.10  % Time Elapsed:   4.51 s
Iteration:  224 Progress:  53.33  % Time Elapsed:   4.53 s
Iteration:  225 Progress:  53.57  % Time Elapsed:   4.55 s
Iteration:  226 Progress:  53.81  % Time Elapsed:   4.57 s
Iteration:  227 Progress:  54.05  % Time Elapsed:   4.59 s
Iteration:  228 Progress:  54.29  % Time Elapsed:   4.61 s
Iteration:  229 Progress:  54.52  % Time Elapsed:   4.63 s
Iteration:  230 Progress:  54.76  % Time Elapsed:   4.64 s
Iteration:  231 Progress:  55.00  % Time Elapsed:   4.66 s
Epoch 10 Finished.  Time per Epoch:   0.42 s
Iteration:  232 Progress:  55.24  % Time Elapsed:   4.68 s
Iteration:  233 Progress:  55.48  % Time Elapsed:   4.70 s
Iteration:  234 Progress:  55.71  % Time Elapsed:   4.72 s
Iteration:  235 Progress:  55.95  % Time Elapsed:   4.74 s
Iteration:  236 Progress:  56.19  % Time Elapsed:   4.76 s
Iteration:  237 Progress:  56.43  % Time Elapsed:   4.78 s
Iteration:  238 Progress:  56.67  % Time Elapsed:   4.80 s
Iteration:  239 Progress:  56.90  % Time Elapsed:   4.82 s
Iteration:  240 Progress:  57.14  % Time Elapsed:   4.84 s
Iteration:  241 Progress:  57.38  % Time Elapsed:   4.86 s
Iteration:  242 Progress:  57.62  % Time Elapsed:   4.88 s
Iteration:  243 Progress:  57.86  % Time Elapsed:   4.89 s
Iteration:  244 Progress:  58.10  % Time Elapsed:   4.91 s
Iteration:  245 Progress:  58.33  % Time Elapsed:   4.93 s
Iteration:  246 Progress:  58.57  % Time Elapsed:   4.95 s
Iteration:  247 Progress:  58.81  % Time Elapsed:   4.97 s
Iteration:  248 Progress:  59.05  % Time Elapsed:   4.99 s
Iteration:  249 Progress:  59.29  % Time Elapsed:   5.01 s
Iteration:  250 Progress:  59.52  % Time Elapsed:   5.03 s
Iteration:  251 Progress:  59.76  % Time Elapsed:   5.05 s
Iteration:  252 Progress:  60.00  % Time Elapsed:   5.07 s
Epoch 11 Finished.  Time per Epoch:   0.42 s
Iteration:  253 Progress:  60.24  % Time Elapsed:   5.09 s
Iteration:  254 Progress:  60.48  % Time Elapsed:   5.10 s
Iteration:  255 Progress:  60.71  % Time Elapsed:   5.12 s
Iteration:  256 Progress:  60.95  % Time Elapsed:   5.14 s
Iteration:  257 Progress:  61.19  % Time Elapsed:   5.16 s
Iteration:  258 Progress:  61.43  % Time Elapsed:   5.18 s
Iteration:  259 Progress:  61.67  % Time Elapsed:   5.20 s
Iteration:  260 Progress:  61.90  % Time Elapsed:   5.22 s
Iteration:  261 Progress:  62.14  % Time Elapsed:   5.24 s
Iteration:  262 Progress:  62.38  % Time Elapsed:   5.25 s
Iteration:  263 Progress:  62.62  % Time Elapsed:   5.27 s
Iteration:  264 Progress:  62.86  % Time Elapsed:   5.30 s
Iteration:  265 Progress:  63.10  % Time Elapsed:   5.31 s
Iteration:  266 Progress:  63.33  % Time Elapsed:   5.33 s
Iteration:  267 Progress:  63.57  % Time Elapsed:   5.35 s
```

```
Iteration:  268 Progress:  63.81  % Time Elapsed:   5.38 s
Iteration:  269 Progress:  64.05  % Time Elapsed:   5.41 s
Iteration:  270 Progress:  64.29  % Time Elapsed:   5.42 s
Iteration:  271 Progress:  64.52  % Time Elapsed:   5.44 s
Iteration:  272 Progress:  64.76  % Time Elapsed:   5.46 s
Iteration:  273 Progress:  65.00  % Time Elapsed:   5.48 s
Epoch 12 Finished.  Time per Epoch:   0.42 s
Iteration:  274 Progress:  65.24  % Time Elapsed:   5.50 s
Iteration:  275 Progress:  65.48  % Time Elapsed:   5.52 s
Iteration:  276 Progress:  65.71  % Time Elapsed:   5.54 s
Iteration:  277 Progress:  65.95  % Time Elapsed:   5.56 s
Iteration:  278 Progress:  66.19  % Time Elapsed:   5.58 s
Iteration:  279 Progress:  66.43  % Time Elapsed:   5.61 s
Iteration:  280 Progress:  66.67  % Time Elapsed:   5.62 s
Iteration:  281 Progress:  66.90  % Time Elapsed:   5.64 s
Iteration:  282 Progress:  67.14  % Time Elapsed:   5.66 s
Iteration:  283 Progress:  67.38  % Time Elapsed:   5.68 s
Iteration:  284 Progress:  67.62  % Time Elapsed:   5.70 s
Iteration:  285 Progress:  67.86  % Time Elapsed:   5.72 s
Iteration:  286 Progress:  68.10  % Time Elapsed:   5.74 s
Iteration:  287 Progress:  68.33  % Time Elapsed:   5.76 s
Iteration:  288 Progress:  68.57  % Time Elapsed:   5.78 s
Iteration:  289 Progress:  68.81  % Time Elapsed:   5.80 s
Iteration:  290 Progress:  69.05  % Time Elapsed:   5.82 s
Iteration:  291 Progress:  69.29  % Time Elapsed:   5.84 s
Iteration:  292 Progress:  69.52  % Time Elapsed:   5.86 s
Iteration:  293 Progress:  69.76  % Time Elapsed:   5.87 s
Iteration:  294 Progress:  70.00  % Time Elapsed:   5.89 s
Epoch 13 Finished.  Time per Epoch:   0.42 s
Iteration:  295 Progress:  70.24  % Time Elapsed:   5.91 s
Iteration:  296 Progress:  70.48  % Time Elapsed:   5.93 s
Iteration:  297 Progress:  70.71  % Time Elapsed:   5.95 s
Iteration:  298 Progress:  70.95  % Time Elapsed:   5.97 s
Iteration:  299 Progress:  71.19  % Time Elapsed:   5.99 s
Iteration:  300 Progress:  71.43  % Time Elapsed:   6.01 s
Iteration:  301 Progress:  71.67  % Time Elapsed:   6.03 s
Iteration:  302 Progress:  71.90  % Time Elapsed:   6.06 s
Iteration:  303 Progress:  72.14  % Time Elapsed:   6.08 s
Iteration:  304 Progress:  72.38  % Time Elapsed:   6.10 s
Iteration:  305 Progress:  72.62  % Time Elapsed:   6.12 s
Iteration:  306 Progress:  72.86  % Time Elapsed:   6.14 s
Iteration:  307 Progress:  73.10  % Time Elapsed:   6.16 s
Iteration:  308 Progress:  73.33  % Time Elapsed:   6.18 s
Iteration:  309 Progress:  73.57  % Time Elapsed:   6.20 s
Iteration:  310 Progress:  73.81  % Time Elapsed:   6.22 s
Iteration:  311 Progress:  74.05  % Time Elapsed:   6.24 s
Iteration:  312 Progress:  74.29  % Time Elapsed:   6.27 s
Iteration:  313 Progress:  74.52  % Time Elapsed:   6.29 s
Iteration:  314 Progress:  74.76  % Time Elapsed:   6.31 s
Iteration:  315 Progress:  75.00  % Time Elapsed:   6.34 s
Epoch 14 Finished.  Time per Epoch:   0.42 s
Iteration:  316 Progress:  75.24  % Time Elapsed:   6.36 s
Iteration:  317 Progress:  75.48  % Time Elapsed:   6.38 s
Iteration:  318 Progress:  75.71  % Time Elapsed:   6.40 s
Iteration:  319 Progress:  75.95  % Time Elapsed:   6.43 s
Iteration:  320 Progress:  76.19  % Time Elapsed:   6.45 s
```

```
Iteration:  321 Progress:  76.43  % Time Elapsed:   6.47 s
Iteration:  322 Progress:  76.67  % Time Elapsed:   6.49 s
Iteration:  323 Progress:  76.90  % Time Elapsed:   6.51 s
Iteration:  324 Progress:  77.14  % Time Elapsed:   6.53 s
Iteration:  325 Progress:  77.38  % Time Elapsed:   6.55 s
Iteration:  326 Progress:  77.62  % Time Elapsed:   6.57 s
Iteration:  327 Progress:  77.86  % Time Elapsed:   6.59 s
Iteration:  328 Progress:  78.10  % Time Elapsed:   6.61 s
Iteration:  329 Progress:  78.33  % Time Elapsed:   6.63 s
Iteration:  330 Progress:  78.57  % Time Elapsed:   6.65 s
Iteration:  331 Progress:  78.81  % Time Elapsed:   6.67 s
Iteration:  332 Progress:  79.05  % Time Elapsed:   6.69 s
Iteration:  333 Progress:  79.29  % Time Elapsed:   6.71 s
Iteration:  334 Progress:  79.52  % Time Elapsed:   6.73 s
Iteration:  335 Progress:  79.76  % Time Elapsed:   6.75 s
Iteration:  336 Progress:  80.00  % Time Elapsed:   6.77 s
Epoch 15 Finished.  Time per Epoch:   0.42 s
Iteration:  337 Progress:  80.24  % Time Elapsed:   6.79 s
Iteration:  338 Progress:  80.48  % Time Elapsed:   6.81 s
Iteration:  339 Progress:  80.71  % Time Elapsed:   6.83 s
Iteration:  340 Progress:  80.95  % Time Elapsed:   6.85 s
Iteration:  341 Progress:  81.19  % Time Elapsed:   6.87 s
Iteration:  342 Progress:  81.43  % Time Elapsed:   6.89 s
Iteration:  343 Progress:  81.67  % Time Elapsed:   6.91 s
Iteration:  344 Progress:  81.90  % Time Elapsed:   6.94 s
Iteration:  345 Progress:  82.14  % Time Elapsed:   6.96 s
Iteration:  346 Progress:  82.38  % Time Elapsed:   6.98 s
Iteration:  347 Progress:  82.62  % Time Elapsed:   7.00 s
Iteration:  348 Progress:  82.86  % Time Elapsed:   7.02 s
Iteration:  349 Progress:  83.10  % Time Elapsed:   7.05 s
Iteration:  350 Progress:  83.33  % Time Elapsed:   7.07 s
Iteration:  351 Progress:  83.57  % Time Elapsed:   7.09 s
Iteration:  352 Progress:  83.81  % Time Elapsed:   7.12 s
Iteration:  353 Progress:  84.05  % Time Elapsed:   7.14 s
Iteration:  354 Progress:  84.29  % Time Elapsed:   7.16 s
Iteration:  355 Progress:  84.52  % Time Elapsed:   7.18 s
Iteration:  356 Progress:  84.76  % Time Elapsed:   7.20 s
Iteration:  357 Progress:  85.00  % Time Elapsed:   7.22 s
Epoch 16 Finished.  Time per Epoch:   0.42 s
Iteration:  358 Progress:  85.24  % Time Elapsed:   7.24 s
Iteration:  359 Progress:  85.48  % Time Elapsed:   7.26 s
Iteration:  360 Progress:  85.71  % Time Elapsed:   7.28 s
Iteration:  361 Progress:  85.95  % Time Elapsed:   7.30 s
Iteration:  362 Progress:  86.19  % Time Elapsed:   7.32 s
Iteration:  363 Progress:  86.43  % Time Elapsed:   7.34 s
Iteration:  364 Progress:  86.67  % Time Elapsed:   7.36 s
Iteration:  365 Progress:  86.90  % Time Elapsed:   7.38 s
Iteration:  366 Progress:  87.14  % Time Elapsed:   7.40 s
Iteration:  367 Progress:  87.38  % Time Elapsed:   7.42 s
Iteration:  368 Progress:  87.62  % Time Elapsed:   7.44 s
Iteration:  369 Progress:  87.86  % Time Elapsed:   7.47 s
Iteration:  370 Progress:  88.10  % Time Elapsed:   7.49 s
Iteration:  371 Progress:  88.33  % Time Elapsed:   7.52 s
Iteration:  372 Progress:  88.57  % Time Elapsed:   7.54 s
Iteration:  373 Progress:  88.81  % Time Elapsed:   7.56 s
Iteration:  374 Progress:  89.05  % Time Elapsed:   7.58 s
```

```
Iteration:  375 Progress:  89.29  % Time Elapsed:   7.60 s
Iteration:  376 Progress:  89.52  % Time Elapsed:   7.62 s
Iteration:  377 Progress:  89.76  % Time Elapsed:   7.64 s
Iteration:  378 Progress:  90.00  % Time Elapsed:   7.66 s
Epoch 17 Finished.  Time per Epoch:   0.43 s
Iteration:  379 Progress:  90.24  % Time Elapsed:   7.68 s
Iteration:  380 Progress:  90.48  % Time Elapsed:   7.70 s
Iteration:  381 Progress:  90.71  % Time Elapsed:   7.72 s
Iteration:  382 Progress:  90.95  % Time Elapsed:   7.75 s
Iteration:  383 Progress:  91.19  % Time Elapsed:   7.76 s
Iteration:  384 Progress:  91.43  % Time Elapsed:   7.78 s
Iteration:  385 Progress:  91.67  % Time Elapsed:   7.81 s
Iteration:  386 Progress:  91.90  % Time Elapsed:   7.83 s
Iteration:  387 Progress:  92.14  % Time Elapsed:   7.85 s
Iteration:  388 Progress:  92.38  % Time Elapsed:   7.88 s
Iteration:  389 Progress:  92.62  % Time Elapsed:   7.90 s
Iteration:  390 Progress:  92.86  % Time Elapsed:   7.92 s
Iteration:  391 Progress:  93.10  % Time Elapsed:   7.94 s
Iteration:  392 Progress:  93.33  % Time Elapsed:   7.96 s
Iteration:  393 Progress:  93.57  % Time Elapsed:   7.98 s
Iteration:  394 Progress:  93.81  % Time Elapsed:   8.00 s
Iteration:  395 Progress:  94.05  % Time Elapsed:   8.02 s
Iteration:  396 Progress:  94.29  % Time Elapsed:   8.04 s
Iteration:  397 Progress:  94.52  % Time Elapsed:   8.05 s
Iteration:  398 Progress:  94.76  % Time Elapsed:   8.07 s
Iteration:  399 Progress:  95.00  % Time Elapsed:   8.09 s
Epoch 18 Finished.  Time per Epoch:   0.43 s
Iteration:  400 Progress:  95.24  % Time Elapsed:   8.11 s
Iteration:  401 Progress:  95.48  % Time Elapsed:   8.13 s
Iteration:  402 Progress:  95.71  % Time Elapsed:   8.15 s
Iteration:  403 Progress:  95.95  % Time Elapsed:   8.17 s
Iteration:  404 Progress:  96.19  % Time Elapsed:   8.19 s
Iteration:  405 Progress:  96.43  % Time Elapsed:   8.21 s
Iteration:  406 Progress:  96.67  % Time Elapsed:   8.23 s
Iteration:  407 Progress:  96.90  % Time Elapsed:   8.25 s
Iteration:  408 Progress:  97.14  % Time Elapsed:   8.27 s
Iteration:  409 Progress:  97.38  % Time Elapsed:   8.29 s
Iteration:  410 Progress:  97.62  % Time Elapsed:   8.31 s
Iteration:  411 Progress:  97.86  % Time Elapsed:   8.34 s
Iteration:  412 Progress:  98.10  % Time Elapsed:   8.36 s
Iteration:  413 Progress:  98.33  % Time Elapsed:   8.38 s
Iteration:  414 Progress:  98.57  % Time Elapsed:   8.41 s
Iteration:  415 Progress:  98.81  % Time Elapsed:   8.43 s
Iteration:  416 Progress:  99.05  % Time Elapsed:   8.45 s
Iteration:  417 Progress:  99.29  % Time Elapsed:   8.48 s
Iteration:  418 Progress:  99.52  % Time Elapsed:   8.52 s
Iteration:  419 Progress:  99.76  % Time Elapsed:   8.55 s
Iteration:  420 Progress:  100.00  % Time Elapsed:   8.59 s
Epoch 19 Finished.  Time per Epoch:   0.43 s
```


Training Curve
Loss
0.014
0.012
0.010
0.008
0.006
0
100
200
300
400
Iterations


Training Curve
Training
Validation
Validation Accuracy
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0
100
200
300
400
Iterations

```
Final Training Accuracy: 0.2336589030803907
Final Validation Accuracy: 0.18510158013544017
Total time:    8.59 s  Time per Epoch:   0.43 s
```

The best model is batch_size=256, num_epochs=20, lr=0.02 with results:

Final Training Accuracy: 0.9992486851990984

Final Validation Accuracy: 0.9322799097065463

Part (d) - 2 pt

Report the test accuracy of your best model. How does the test accuracy compare to Part 3(d) without transfer learning?

In [ ]:
```
final_model = Gesture_Alex()
test_loader = torch.utils.data.DataLoader(test_loader_feature, batch_size=256, shuf
#batch_size=256, num_epochs=20, lr=0.02)

final_model.load_state_dict(torch.load('Gesture_Alex_bs256_lr0.02_epoch20'))
correct = 0
total = 0
batch_size = 64
use_cuda = True
if use_cuda and torch.cuda.is_available():
  final_model.cuda()
  print('CUDA is available!  Training on GPU ...')
else:
  print('CUDA is not available.  Training on CPU ...')
for imgs, labels in torch.utils.data.DataLoader(test_features_dataset, batch_size=b
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
           imgs = imgs.cuda()
           labels = labels.cuda()
        output = final_model(imgs)

        #select index with maximum prediction score
        pred = output.max(1, keepdim=True)[1]
        correct += pred.eq(labels.view_as(pred)).sum().item()
        total += imgs.shape[0]
print("Test Accuracy: ",correct/total)
```

```
CUDA is not available.  Training on CPU ...
Test Accuracy:  0.9393258426966292
```

The Test Accuracy: 0.9393 (93.9%) with transfer learning is compared to Part3(d) Test Accuracy: 0.8539325842696629 (85.4%). The Gesture Alex model is (8.5%) percent better.

In [58]:
```
!jupyter nbconvert --to html /content/gdrive/MyDrive/ColabNotebooks/Lab3GestureReco
```

```
[NbConvertApp] Converting notebook /content/gdrive/MyDrive/ColabNotebooks/Lab3GestureRecognition.ipynb to html
[NbConvertApp] WARNING | Alternative text is missing on 16 image(s).
[NbConvertApp] Writing 1449622 bytes to /content/gdrive/MyDrive/ColabNotebooks/Lab3GestureRecognition.html
```