Machine Learning Project 07 completed

November 21, 2019

[1]:
```
import torch
from torch.utils.data import Dataset, DataLoader
import torchvision.transforms as transforms
from torch.autograd import Variable
import torchvision
import os
import sys

#from scipy.special import xlogy

import matplotlib.pyplot as plt
import numpy as np
import time


transform = transforms.Compose([#transforms.Resize((256,256)),
                                transforms.Grayscale(),                 # the␣
 ↪code transforms.Graysclae() is for changing the size [3,100,100] to [1, 100,␣
 ↪100] (notice : [channel, height, width] )
                                transforms.ToTensor(),])


#train_data_path = 'relative path of training data set'
train_data_path = 'C:\\Users\\newmi\\OneDrive\\ ␣
 ↪ \\horse-or-human\\horse-or-human\\train'
trainset = torchvision.datasets.ImageFolder(root=train_data_path,␣
 ↪transform=transform)
# change the valuse of batch_size, num_workers for your program
# if shuffle=True, the data reshuffled at every epoch
loader_train = torch.utils.data.DataLoader(trainset, batch_size=30,␣
 ↪shuffle=False, num_workers=1)


validation_data_path = 'C:\\Users\\newmi\\OneDrive\\ ␣
 ↪ \\horse-or-human\\horse-or-human\\validation'
valset = torchvision.datasets.ImageFolder(root=validation_data_path,␣
 ↪transform=transform)
```

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# change the valuse of batch_size, num_workers for your program
loader_test = torch.utils.data.DataLoader(valset, batch_size=30, shuffle=False,␣
 ↪num_workers=1)
```

[357]:
```
import torch
import torchvision.datasets as dsets
import torchvision.transforms as transforms
import random


device = 'cuda' if torch.cuda.is_available() else 'cpu'

if device == 'cuda':
    torch.cuda.manual_seed_all(777)

random.seed(111)
torch.manual_seed(777)
mnist_train=trainset
mnist_test =valset


# ------------------------------------------------------------------------
# Initailizaion option
# ------------------------------------------------------------------------

epochs = 153
batch_size = 8
learning_rate = 0.0001
weight_decay=1

loader_train = torch.utils.data.DataLoader(mnist_train, batch_size=batch_size,␣
 ↪shuffle=True, drop_last=True)
loader_test= torch.utils.data.DataLoader(mnist_test, batch_size=batch_size,␣
 ↪shuffle=True, drop_last=True)
linear1 = torch.nn.Linear(100*100, 50, bias=True)
linear2 = torch.nn.Linear(50,50, bias=True)
linear3 = torch.nn.Linear(50,11, bias=True)
relu = torch.nn.ReLU()
torch.nn.init.normal_(linear1.weight)
torch.nn.init.normal_(linear2.weight)
torch.nn.init.normal_(linear3.weight)


model = torch.nn.Sequential(linear1, relu, linear2, relu, linear3).to(device)

# ------------------------------------------------------------------------
# optimization algorithm
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# ------------------------------------------------------------------------------


loss_function = torch.nn.CrossEntropyLoss().to(device)
optimizer = torch.optim.SGD(model.parameters(),␣
 ↪lr=learning_rate,weight_decay=weight_decay)


# ------------------------------------------------------------------------------
# Initialization of loss array and accuracy array
# ------------------------------------------------------------------------------


loss_train_mean        = np.zeros(epochs)
loss_train_std         = np.zeros(epochs)
accuracy_train         = np.zeros(epochs)
accuracy_train_std     = np.zeros(epochs)

loss_test_mean          = np.zeros(epochs)
loss_test_std          = np.zeros(epochs)
accuracy_test          = np.zeros(epochs)

# ------------------------------------------------------------------------------
# Calculating for training the model
# ------------------------------------------------------------------------------

print('start')
for epoch in range(epochs):


    avg_loss_train = 0
    batch_count_train = len(loader_train)
    running_corrects_train = 0
    loss_accuracy          = []
    loss_train             = []


    for X, Y in loader_train:

        X = X.view(-1, 100*100).to(device)
        Y = Y.to(device)
        prediction = model(X)
        _, preds = torch.max(prediction, 1)
        loss = loss_function(prediction, Y)

        optimizer.zero_grad()
        loss.backward()
```

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        optimizer.step()


        loss_train_batch       =loss.item()/len(X)
        loss_train.append(loss_train_batch)
        running_corrects_train += torch.sum(preds == Y).item() /␣
↪900#len(loader_train.dataset)
        loss_accuracy.append(running_corrects_train)


    loss_train_mean[epoch]     = np.mean(loss_train)
    loss_train_std[epoch]      = np.std(loss_train)
    accuracy_train_std[epoch]  = np.std(loss_accuracy)
    accuracy_train[epoch]=running_corrects_train

  #  for X,Y in loader_test

    avg_loss_test         = 0
    batch_count_test      = len(loader_test)
    running_corrects_test = 0
    loss_test              = []

    for datas, labels in loader_test:

        datas         = datas.view(-1, 100*100).to(device)
        labels        = labels.to(device)
        prediction    = model(datas)
        _, preds_test = torch.max(prediction, 1)
        loss          = loss_function(prediction,labels)


        loss_test_batch       =loss.item()/len(datas)
        loss_test.append(loss_test_batch)
        running_corrects_test += torch.sum(preds_test == labels).item()


    loss_test_mean[epoch]       = np.mean(loss_test)
    running_corrects_test       = running_corrects_test / 250#len(loader_test.
↪dataset)
    accuracy_test[epoch]        = running_corrects_test

    print("""[EPOCH %4d ] LOSS     :(TRAIN) %3.10f        (TEST): %3.10f
              ACCURACY :(TRAIN) %3.10f%%       (TEST): %3.
↪10f%%\n"""%(epoch,loss_train_batch,loss_test_batch,(running_corrects_train*100),(running_co
```

```
start
[EPOCH    0 ] LOSS     :(TRAIN) 1.7101622820        (TEST): 7.5678787231
```

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              ACCURACY :(TRAIN) 49.8888888889%       (TEST): 62.8000000000%

[EPOCH    1 ] LOSS     :(TRAIN) 10.6595630646        (TEST): 11.3186035156
              ACCURACY :(TRAIN) 68.3333333333%       (TEST): 69.2000000000%

[EPOCH    2 ] LOSS     :(TRAIN) 2.8114550114        (TEST): 6.7598609924
              ACCURACY :(TRAIN) 71.2222222222%       (TEST): 69.6000000000%

[EPOCH    3 ] LOSS     :(TRAIN) 4.2264733315        (TEST): 3.7534179688
              ACCURACY :(TRAIN) 74.7777777778%       (TEST): 76.8000000000%

[EPOCH    4 ] LOSS     :(TRAIN) 1.4688758850        (TEST): 0.0000006631
              ACCURACY :(TRAIN) 77.4444444444%       (TEST): 78.0000000000%

[EPOCH    5 ] LOSS     :(TRAIN) 0.2081146538        (TEST): 8.4846649170
              ACCURACY :(TRAIN) 75.3333333333%       (TEST): 73.6000000000%

[EPOCH    6 ] LOSS     :(TRAIN) 1.2081222534        (TEST): 5.3128433228
              ACCURACY :(TRAIN) 76.7777777778%       (TEST): 76.4000000000%

[EPOCH    7 ] LOSS     :(TRAIN) 3.2477390766        (TEST): 2.7831389904
              ACCURACY :(TRAIN) 76.8888888889%       (TEST): 83.2000000000%

[EPOCH    8 ] LOSS     :(TRAIN) 2.1362209320        (TEST): 0.0000000000
              ACCURACY :(TRAIN) 78.4444444444%       (TEST): 79.2000000000%

[EPOCH    9 ] LOSS     :(TRAIN) 4.8848609924        (TEST): 3.4705963135
              ACCURACY :(TRAIN) 77.7777777778%       (TEST): 70.4000000000%

[EPOCH   10 ] LOSS     :(TRAIN) 1.5108711720        (TEST): 1.7557337284
              ACCURACY :(TRAIN) 78.0000000000%       (TEST): 85.6000000000%

[EPOCH   11 ] LOSS     :(TRAIN) 1.4595975876        (TEST): 1.4738998413
              ACCURACY :(TRAIN) 80.0000000000%       (TEST): 70.8000000000%

[EPOCH   12 ] LOSS     :(TRAIN) 2.2557175159        (TEST): 1.4123878479
              ACCURACY :(TRAIN) 80.8888888889%       (TEST): 86.0000000000%

[EPOCH   13 ] LOSS     :(TRAIN) 1.3138551712        (TEST): 1.5129566193
              ACCURACY :(TRAIN) 81.0000000000%       (TEST): 84.4000000000%

[EPOCH   14 ] LOSS     :(TRAIN) 1.2949386835        (TEST): 0.9536170959
              ACCURACY :(TRAIN) 82.2222222222%       (TEST): 77.6000000000%

[EPOCH   15 ] LOSS     :(TRAIN) 0.8715671897        (TEST): 0.0000000019
              ACCURACY :(TRAIN) 81.0000000000%       (TEST): 72.4000000000%

[EPOCH   16 ] LOSS     :(TRAIN) 0.3827417791        (TEST): 0.1433388740
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              ACCURACY :(TRAIN) 83.4444444444%       (TEST): 84.0000000000%

[EPOCH   17 ] LOSS     :(TRAIN) 0.5972720385        (TEST): 0.0000000000
              ACCURACY :(TRAIN) 83.1111111111%       (TEST): 85.6000000000%

[EPOCH   18 ] LOSS     :(TRAIN) 1.0651102066        (TEST): 0.2868421674
              ACCURACY :(TRAIN) 82.0000000000%       (TEST): 85.2000000000%

[EPOCH   19 ] LOSS     :(TRAIN) 0.4663712382        (TEST): 2.0420131683
              ACCURACY :(TRAIN) 82.6666666667%       (TEST): 74.4000000000%

[EPOCH   20 ] LOSS     :(TRAIN) 0.7583829761        (TEST): 0.7109985352
              ACCURACY :(TRAIN) 84.8888888889%       (TEST): 82.4000000000%

[EPOCH   21 ] LOSS     :(TRAIN) 0.5283318758        (TEST): 0.0087740626
              ACCURACY :(TRAIN) 84.3333333333%       (TEST): 82.0000000000%

[EPOCH   22 ] LOSS     :(TRAIN) 0.1836417913        (TEST): 1.3823264837
              ACCURACY :(TRAIN) 83.7777777778%       (TEST): 81.6000000000%

[EPOCH   23 ] LOSS     :(TRAIN) 0.5266298056        (TEST): 1.2149221897
              ACCURACY :(TRAIN) 81.4444444444%       (TEST): 66.8000000000%

[EPOCH   24 ] LOSS     :(TRAIN) 0.3542418778        (TEST): 1.4568195343
              ACCURACY :(TRAIN) 82.2222222222%       (TEST): 84.0000000000%

[EPOCH   25 ] LOSS     :(TRAIN) 0.2227140516        (TEST): 0.5291764736
              ACCURACY :(TRAIN) 83.6666666667%       (TEST): 84.4000000000%

[EPOCH   26 ] LOSS     :(TRAIN) 0.1452812850        (TEST): 1.5303027630
              ACCURACY :(TRAIN) 83.3333333333%       (TEST): 66.0000000000%

[EPOCH   27 ] LOSS     :(TRAIN) 0.0026930172        (TEST): 0.3684248626
              ACCURACY :(TRAIN) 85.3333333333%       (TEST): 83.6000000000%

[EPOCH   28 ] LOSS     :(TRAIN) 0.3586052656        (TEST): 0.3123692870
              ACCURACY :(TRAIN) 86.0000000000%       (TEST): 85.6000000000%

[EPOCH   29 ] LOSS     :(TRAIN) 0.0441210940        (TEST): 0.4304371476
              ACCURACY :(TRAIN) 84.5555555556%       (TEST): 82.0000000000%

[EPOCH   30 ] LOSS     :(TRAIN) 0.1276044101        (TEST): 0.0000877297
              ACCURACY :(TRAIN) 85.0000000000%       (TEST): 86.0000000000%

[EPOCH   31 ] LOSS     :(TRAIN) 0.2566736042        (TEST): 0.3251261711
              ACCURACY :(TRAIN) 85.5555555556%       (TEST): 86.4000000000%

[EPOCH   32 ] LOSS     :(TRAIN) 0.4494494200        (TEST): 0.7458223104
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              ACCURACY :(TRAIN) 83.2222222222%       (TEST): 80.8000000000%

[EPOCH   33 ] LOSS     :(TRAIN) 0.8801454902        (TEST): 2.3509998322
              ACCURACY :(TRAIN) 84.1111111111%       (TEST): 60.0000000000%

[EPOCH   34 ] LOSS     :(TRAIN) 0.1400978416        (TEST): 0.4563523233
              ACCURACY :(TRAIN) 85.8888888889%       (TEST): 84.0000000000%

[EPOCH   35 ] LOSS     :(TRAIN) 0.0667186454        (TEST): 0.0379672870
              ACCURACY :(TRAIN) 85.6666666667%       (TEST): 74.0000000000%

[EPOCH   36 ] LOSS     :(TRAIN) 0.4549833238        (TEST): 0.0001682621
              ACCURACY :(TRAIN) 85.4444444444%       (TEST): 73.2000000000%

[EPOCH   37 ] LOSS     :(TRAIN) 0.0821432620        (TEST): 0.5577158928
              ACCURACY :(TRAIN) 86.0000000000%       (TEST): 76.0000000000%

[EPOCH   38 ] LOSS     :(TRAIN) 0.2309833765        (TEST): 0.1449502856
              ACCURACY :(TRAIN) 86.8888888889%       (TEST): 76.4000000000%

[EPOCH   39 ] LOSS     :(TRAIN) 0.0718543455        (TEST): 0.1682496220
              ACCURACY :(TRAIN) 85.7777777778%       (TEST): 84.0000000000%

[EPOCH   40 ] LOSS     :(TRAIN) 0.0128387408        (TEST): 0.1427793354
              ACCURACY :(TRAIN) 87.3333333333%       (TEST): 83.2000000000%

[EPOCH   41 ] LOSS     :(TRAIN) 0.1994519085        (TEST): 0.2404633015
              ACCURACY :(TRAIN) 88.7777777778%       (TEST): 83.2000000000%

[EPOCH   42 ] LOSS     :(TRAIN) 0.1657607108        (TEST): 0.7279039621
              ACCURACY :(TRAIN) 87.1111111111%       (TEST): 69.2000000000%

[EPOCH   43 ] LOSS     :(TRAIN) 0.1356576532        (TEST): 0.2008712292
              ACCURACY :(TRAIN) 87.1111111111%       (TEST): 84.4000000000%

[EPOCH   44 ] LOSS     :(TRAIN) 0.1962220967        (TEST): 0.0021964649
              ACCURACY :(TRAIN) 86.4444444444%       (TEST): 85.6000000000%

[EPOCH   45 ] LOSS     :(TRAIN) 0.0609351024        (TEST): 0.0013723866
              ACCURACY :(TRAIN) 87.1111111111%       (TEST): 86.0000000000%

[EPOCH   46 ] LOSS     :(TRAIN) 0.2113592029        (TEST): 0.3927392364
              ACCURACY :(TRAIN) 86.0000000000%       (TEST): 76.4000000000%

[EPOCH   47 ] LOSS     :(TRAIN) 0.0242394879        (TEST): 0.1471698284
              ACCURACY :(TRAIN) 86.2222222222%       (TEST): 84.4000000000%

[EPOCH   48 ] LOSS     :(TRAIN) 0.0963171646        (TEST): 0.0034536682
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              ACCURACY :(TRAIN) 87.6666666667%       (TEST): 86.4000000000%

[EPOCH   49 ] LOSS     :(TRAIN) 0.0148818213        (TEST): 0.0105860289
              ACCURACY :(TRAIN) 84.8888888889%       (TEST): 85.2000000000%

[EPOCH   50 ] LOSS     :(TRAIN) 0.0112080164        (TEST): 0.2010754049
              ACCURACY :(TRAIN) 87.2222222222%       (TEST): 85.2000000000%

[EPOCH   51 ] LOSS     :(TRAIN) 0.1293967366        (TEST): 0.2527229786
              ACCURACY :(TRAIN) 87.5555555556%       (TEST): 71.6000000000%

[EPOCH   52 ] LOSS     :(TRAIN) 0.0572891831        (TEST): 0.0008219515
              ACCURACY :(TRAIN) 87.1111111111%       (TEST): 86.4000000000%

[EPOCH   53 ] LOSS     :(TRAIN) 0.0367459133        (TEST): 0.0027312939
              ACCURACY :(TRAIN) 87.6666666667%       (TEST): 82.0000000000%

[EPOCH   54 ] LOSS     :(TRAIN) 0.0628332123        (TEST): 0.0494256914
              ACCURACY :(TRAIN) 88.4444444444%       (TEST): 86.8000000000%

[EPOCH   55 ] LOSS     :(TRAIN) 0.1075602844        (TEST): 0.0240656994
              ACCURACY :(TRAIN) 88.2222222222%       (TEST): 85.6000000000%

[EPOCH   56 ] LOSS     :(TRAIN) 0.0105240261        (TEST): 0.0001007967
              ACCURACY :(TRAIN) 87.1111111111%       (TEST): 84.8000000000%

[EPOCH   57 ] LOSS     :(TRAIN) 0.1518491805        (TEST): 0.1231509298
              ACCURACY :(TRAIN) 87.4444444444%       (TEST): 84.8000000000%

[EPOCH   58 ] LOSS     :(TRAIN) 0.1144929528        (TEST): 0.1934154630
              ACCURACY :(TRAIN) 89.3333333333%       (TEST): 87.2000000000%

[EPOCH   59 ] LOSS     :(TRAIN) 0.0084016919        (TEST): 0.0752337500
              ACCURACY :(TRAIN) 87.2222222222%       (TEST): 84.0000000000%

[EPOCH   60 ] LOSS     :(TRAIN) 0.0839517415        (TEST): 0.0617179014
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 86.4000000000%

[EPOCH   61 ] LOSS     :(TRAIN) 0.0247109495        (TEST): 0.0721326396
              ACCURACY :(TRAIN) 88.7777777778%       (TEST): 86.8000000000%

[EPOCH   62 ] LOSS     :(TRAIN) 0.0551798232        (TEST): 0.1147199199
              ACCURACY :(TRAIN) 89.4444444444%       (TEST): 82.8000000000%

[EPOCH   63 ] LOSS     :(TRAIN) 0.0550542511        (TEST): 0.0954831541
              ACCURACY :(TRAIN) 88.8888888889%       (TEST): 84.4000000000%

[EPOCH   64 ] LOSS     :(TRAIN) 0.0348847583        (TEST): 0.1705477834
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              ACCURACY :(TRAIN) 89.0000000000%       (TEST): 80.0000000000%

[EPOCH   65 ] LOSS     :(TRAIN) 0.1160974205        (TEST): 0.0382045433
              ACCURACY :(TRAIN) 88.6666666667%       (TEST): 87.6000000000%

[EPOCH   66 ] LOSS     :(TRAIN) 0.1075214893        (TEST): 0.3259455562
              ACCURACY :(TRAIN) 89.7777777778%       (TEST): 76.0000000000%

[EPOCH   67 ] LOSS     :(TRAIN) 0.0672963113        (TEST): 0.1297023892
              ACCURACY :(TRAIN) 87.5555555556%       (TEST): 82.8000000000%

[EPOCH   68 ] LOSS     :(TRAIN) 0.0695476681        (TEST): 0.1164123341
              ACCURACY :(TRAIN) 88.4444444444%       (TEST): 86.4000000000%

[EPOCH   69 ] LOSS     :(TRAIN) 0.0917822719        (TEST): 0.1482853293
              ACCURACY :(TRAIN) 89.0000000000%       (TEST): 84.8000000000%

[EPOCH   70 ] LOSS     :(TRAIN) 0.0133291455        (TEST): 0.0718310401
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 83.6000000000%

[EPOCH   71 ] LOSS     :(TRAIN) 0.0995956957        (TEST): 0.1194402575
              ACCURACY :(TRAIN) 88.1111111111%       (TEST): 84.8000000000%

[EPOCH   72 ] LOSS     :(TRAIN) 0.0288109295        (TEST): 0.0302637126
              ACCURACY :(TRAIN) 90.5555555556%       (TEST): 85.6000000000%

[EPOCH   73 ] LOSS     :(TRAIN) 0.0527779311        (TEST): 0.1338444650
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 86.0000000000%

[EPOCH   74 ] LOSS     :(TRAIN) 0.0229614396        (TEST): 0.0180826597
              ACCURACY :(TRAIN) 90.5555555556%       (TEST): 86.0000000000%

[EPOCH   75 ] LOSS     :(TRAIN) 0.0369064957        (TEST): 0.0287452228
              ACCURACY :(TRAIN) 90.6666666667%       (TEST): 84.8000000000%

[EPOCH   76 ] LOSS     :(TRAIN) 0.0302421339        (TEST): 0.0308970548
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 80.4000000000%

[EPOCH   77 ] LOSS     :(TRAIN) 0.0536190085        (TEST): 0.0378732942
              ACCURACY :(TRAIN) 89.6666666667%       (TEST): 86.4000000000%

[EPOCH   78 ] LOSS     :(TRAIN) 0.0417512991        (TEST): 0.0408754349
              ACCURACY :(TRAIN) 90.6666666667%       (TEST): 84.0000000000%

[EPOCH   79 ] LOSS     :(TRAIN) 0.0448198803        (TEST): 0.0310317148
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 86.0000000000%

[EPOCH   80 ] LOSS     :(TRAIN) 0.0873731524        (TEST): 0.0619093478
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              ACCURACY :(TRAIN) 91.2222222222%       (TEST): 82.8000000000%

[EPOCH   81 ] LOSS     :(TRAIN) 0.0353192016        (TEST): 0.1316240281
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 86.0000000000%

[EPOCH   82 ] LOSS     :(TRAIN) 0.0369498655        (TEST): 0.0601974316
              ACCURACY :(TRAIN) 92.2222222222%       (TEST): 86.0000000000%

[EPOCH   83 ] LOSS     :(TRAIN) 0.0710086226        (TEST): 0.1034784392
              ACCURACY :(TRAIN) 90.6666666667%       (TEST): 86.4000000000%

[EPOCH   84 ] LOSS     :(TRAIN) 0.0724884570        (TEST): 0.0293114018
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 86.0000000000%

[EPOCH   85 ] LOSS     :(TRAIN) 0.0472045429        (TEST): 0.0215565134
              ACCURACY :(TRAIN) 91.7777777778%       (TEST): 86.0000000000%

[EPOCH   86 ] LOSS     :(TRAIN) 0.0371654704        (TEST): 0.0429020561
              ACCURACY :(TRAIN) 91.2222222222%       (TEST): 86.4000000000%

[EPOCH   87 ] LOSS     :(TRAIN) 0.0482804365        (TEST): 0.0716337562
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 86.8000000000%

[EPOCH   88 ] LOSS     :(TRAIN) 0.0612736642        (TEST): 0.0144867953
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 86.4000000000%

[EPOCH   89 ] LOSS     :(TRAIN) 0.0810004100        (TEST): 0.0416279621
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 86.0000000000%

[EPOCH   90 ] LOSS     :(TRAIN) 0.0704543069        (TEST): 0.0594339892
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 86.0000000000%

[EPOCH   91 ] LOSS     :(TRAIN) 0.0577649362        (TEST): 0.0337428562
              ACCURACY :(TRAIN) 92.0000000000%       (TEST): 85.2000000000%

[EPOCH   92 ] LOSS     :(TRAIN) 0.0663521439        (TEST): 0.0569543764
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 86.4000000000%

[EPOCH   93 ] LOSS     :(TRAIN) 0.0870496929        (TEST): 0.1062039062
              ACCURACY :(TRAIN) 90.1111111111%       (TEST): 81.2000000000%

[EPOCH   94 ] LOSS     :(TRAIN) 0.0474336371        (TEST): 0.0675864220
              ACCURACY :(TRAIN) 91.1111111111%       (TEST): 86.0000000000%

[EPOCH   95 ] LOSS     :(TRAIN) 0.0492111146        (TEST): 0.0489912480
              ACCURACY :(TRAIN) 91.2222222222%       (TEST): 85.6000000000%

[EPOCH   96 ] LOSS     :(TRAIN) 0.0523931384        (TEST): 0.1434294730
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              ACCURACY :(TRAIN) 91.6666666667%       (TEST): 82.4000000000%

[EPOCH   97 ] LOSS     :(TRAIN) 0.0822136998        (TEST): 0.0775748491
              ACCURACY :(TRAIN) 90.8888888889%       (TEST): 87.2000000000%

[EPOCH   98 ] LOSS     :(TRAIN) 0.0353695638        (TEST): 0.0502970703
              ACCURACY :(TRAIN) 91.7777777778%       (TEST): 84.8000000000%

[EPOCH   99 ] LOSS     :(TRAIN) 0.0478905588        (TEST): 0.0423120297
              ACCURACY :(TRAIN) 91.5555555556%       (TEST): 86.8000000000%

[EPOCH  100 ] LOSS     :(TRAIN) 0.0525768138        (TEST): 0.0886075199
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 87.2000000000%

[EPOCH  101 ] LOSS     :(TRAIN) 0.0512108617        (TEST): 0.0998589620
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 86.0000000000%

[EPOCH  102 ] LOSS     :(TRAIN) 0.0699735284        (TEST): 0.0772321075
              ACCURACY :(TRAIN) 91.4444444444%       (TEST): 87.2000000000%

[EPOCH  103 ] LOSS     :(TRAIN) 0.0683528855        (TEST): 0.0675860792
              ACCURACY :(TRAIN) 90.8888888889%       (TEST): 86.4000000000%

[EPOCH  104 ] LOSS     :(TRAIN) 0.0287633762        (TEST): 0.0543810278
              ACCURACY :(TRAIN) 91.8888888889%       (TEST): 87.2000000000%

[EPOCH  105 ] LOSS     :(TRAIN) 0.0837516859        (TEST): 0.0408375114
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 87.6000000000%

[EPOCH  106 ] LOSS     :(TRAIN) 0.0790963024        (TEST): 0.0680795461
              ACCURACY :(TRAIN) 91.7777777778%       (TEST): 87.2000000000%

[EPOCH  107 ] LOSS     :(TRAIN) 0.0713751391        (TEST): 0.0419438407
              ACCURACY :(TRAIN) 91.1111111111%       (TEST): 87.2000000000%

[EPOCH  108 ] LOSS     :(TRAIN) 0.0514049567        (TEST): 0.0256325249
              ACCURACY :(TRAIN) 91.3333333333%       (TEST): 87.2000000000%

[EPOCH  109 ] LOSS     :(TRAIN) 0.0806162804        (TEST): 0.0650787503
              ACCURACY :(TRAIN) 91.1111111111%       (TEST): 86.8000000000%

[EPOCH  110 ] LOSS     :(TRAIN) 0.0530632548        (TEST): 0.0478601977
              ACCURACY :(TRAIN) 90.8888888889%       (TEST): 88.4000000000%

[EPOCH  111 ] LOSS     :(TRAIN) 0.0772599727        (TEST): 0.0342754796
              ACCURACY :(TRAIN) 91.2222222222%       (TEST): 87.2000000000%

[EPOCH  112 ] LOSS     :(TRAIN) 0.0673160926        (TEST): 0.0590111613
```

```
              ACCURACY :(TRAIN) 90.6666666667%       (TEST): 88.0000000000%

[EPOCH  113 ] LOSS     :(TRAIN) 0.0529230051        (TEST): 0.0232043155
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 88.0000000000%

[EPOCH  114 ] LOSS     :(TRAIN) 0.0569535457        (TEST): 0.0534576476
              ACCURACY :(TRAIN) 91.1111111111%       (TEST): 87.2000000000%

[EPOCH  115 ] LOSS     :(TRAIN) 0.0561788306        (TEST): 0.0206116345
              ACCURACY :(TRAIN) 91.0000000000%       (TEST): 88.0000000000%

[EPOCH  116 ] LOSS     :(TRAIN) 0.0535793230        (TEST): 0.0849098042
              ACCURACY :(TRAIN) 91.3333333333%       (TEST): 85.2000000000%

[EPOCH  117 ] LOSS     :(TRAIN) 0.0522100180        (TEST): 0.0675779283
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 86.4000000000%

[EPOCH  118 ] LOSS     :(TRAIN) 0.0703808591        (TEST): 0.0606353357
              ACCURACY :(TRAIN) 91.4444444444%       (TEST): 87.6000000000%

[EPOCH  119 ] LOSS     :(TRAIN) 0.0679025352        (TEST): 0.0468985923
              ACCURACY :(TRAIN) 92.0000000000%       (TEST): 88.4000000000%

[EPOCH  120 ] LOSS     :(TRAIN) 0.0556007624        (TEST): 0.0293764975
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 88.4000000000%

[EPOCH  121 ] LOSS     :(TRAIN) 0.0551166721        (TEST): 0.0565171167
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 85.6000000000%

[EPOCH  122 ] LOSS     :(TRAIN) 0.0524467267        (TEST): 0.0683104247
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 88.4000000000%

[EPOCH  123 ] LOSS     :(TRAIN) 0.0731893182        (TEST): 0.0513792261
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 88.4000000000%

[EPOCH  124 ] LOSS     :(TRAIN) 0.0693496093        (TEST): 0.0238928609
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 86.0000000000%

[EPOCH  125 ] LOSS     :(TRAIN) 0.0759429559        (TEST): 0.0245910380
              ACCURACY :(TRAIN) 90.1111111111%       (TEST): 82.8000000000%

[EPOCH  126 ] LOSS     :(TRAIN) 0.0474294089        (TEST): 0.0348118916
              ACCURACY :(TRAIN) 90.1111111111%       (TEST): 88.4000000000%

[EPOCH  127 ] LOSS     :(TRAIN) 0.0809649602        (TEST): 0.0517672747
              ACCURACY :(TRAIN) 90.3333333333%       (TEST): 88.4000000000%

[EPOCH  128 ] LOSS     :(TRAIN) 0.0469507128        (TEST): 0.0762151331
```

```
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 87.6000000000%

[EPOCH  129 ] LOSS     :(TRAIN) 0.1045569777        (TEST): 0.0836037397
              ACCURACY :(TRAIN) 90.7777777778%       (TEST): 87.6000000000%

[EPOCH  130 ] LOSS     :(TRAIN) 0.0512563735        (TEST): 0.0387681983
              ACCURACY :(TRAIN) 90.1111111111%       (TEST): 88.4000000000%

[EPOCH  131 ] LOSS     :(TRAIN) 0.0550930314        (TEST): 0.0327292122
              ACCURACY :(TRAIN) 89.6666666667%       (TEST): 86.0000000000%

[EPOCH  132 ] LOSS     :(TRAIN) 0.0881444886        (TEST): 0.0514562465
              ACCURACY :(TRAIN) 89.7777777778%       (TEST): 88.4000000000%

[EPOCH  133 ] LOSS     :(TRAIN) 0.0706293508        (TEST): 0.0803722143
              ACCURACY :(TRAIN) 90.2222222222%       (TEST): 86.4000000000%

[EPOCH  134 ] LOSS     :(TRAIN) 0.0648734644        (TEST): 0.0869651586
              ACCURACY :(TRAIN) 90.0000000000%       (TEST): 88.8000000000%

[EPOCH  135 ] LOSS     :(TRAIN) 0.0572009310        (TEST): 0.0617421195
              ACCURACY :(TRAIN) 89.3333333333%       (TEST): 87.6000000000%

[EPOCH  136 ] LOSS     :(TRAIN) 0.0831570774        (TEST): 0.1037914082
              ACCURACY :(TRAIN) 89.7777777778%       (TEST): 84.8000000000%

[EPOCH  137 ] LOSS     :(TRAIN) 0.0729062930        (TEST): 0.0657114387
              ACCURACY :(TRAIN) 89.5555555556%       (TEST): 89.6000000000%

[EPOCH  138 ] LOSS     :(TRAIN) 0.0573560633        (TEST): 0.0374204591
              ACCURACY :(TRAIN) 89.7777777778%       (TEST): 88.4000000000%

[EPOCH  139 ] LOSS     :(TRAIN) 0.0557487570        (TEST): 0.1205469370
              ACCURACY :(TRAIN) 89.5555555556%       (TEST): 88.4000000000%

[EPOCH  140 ] LOSS     :(TRAIN) 0.0651108697        (TEST): 0.0366722085
              ACCURACY :(TRAIN) 89.7777777778%       (TEST): 86.4000000000%

[EPOCH  141 ] LOSS     :(TRAIN) 0.0801285878        (TEST): 0.0460619181
              ACCURACY :(TRAIN) 89.4444444444%       (TEST): 89.6000000000%

[EPOCH  142 ] LOSS     :(TRAIN) 0.0755276754        (TEST): 0.0410710946
              ACCURACY :(TRAIN) 89.2222222222%       (TEST): 87.6000000000%

[EPOCH  143 ] LOSS     :(TRAIN) 0.0729495138        (TEST): 0.0571087040
              ACCURACY :(TRAIN) 89.1111111111%       (TEST): 88.4000000000%

[EPOCH  144 ] LOSS     :(TRAIN) 0.0621790513        (TEST): 0.0615073480
```

```
                ACCURACY :(TRAIN) 89.1111111111%       (TEST): 88.8000000000%

[EPOCH  145 ] LOSS     :(TRAIN) 0.0759018660        (TEST): 0.0736735463
                ACCURACY :(TRAIN) 90.1111111111%       (TEST): 87.2000000000%

[EPOCH  146 ] LOSS     :(TRAIN) 0.0521004274        (TEST): 0.0522844791
                ACCURACY :(TRAIN) 89.1111111111%       (TEST): 85.2000000000%

[EPOCH  147 ] LOSS     :(TRAIN) 0.0572534986        (TEST): 0.0634582192
                ACCURACY :(TRAIN) 89.6666666667%       (TEST): 88.8000000000%

[EPOCH  148 ] LOSS     :(TRAIN) 0.0663139075        (TEST): 0.0413329266
                ACCURACY :(TRAIN) 90.0000000000%       (TEST): 89.2000000000%

[EPOCH  149 ] LOSS     :(TRAIN) 0.0503552705        (TEST): 0.0347821116
                ACCURACY :(TRAIN) 90.1111111111%       (TEST): 85.6000000000%

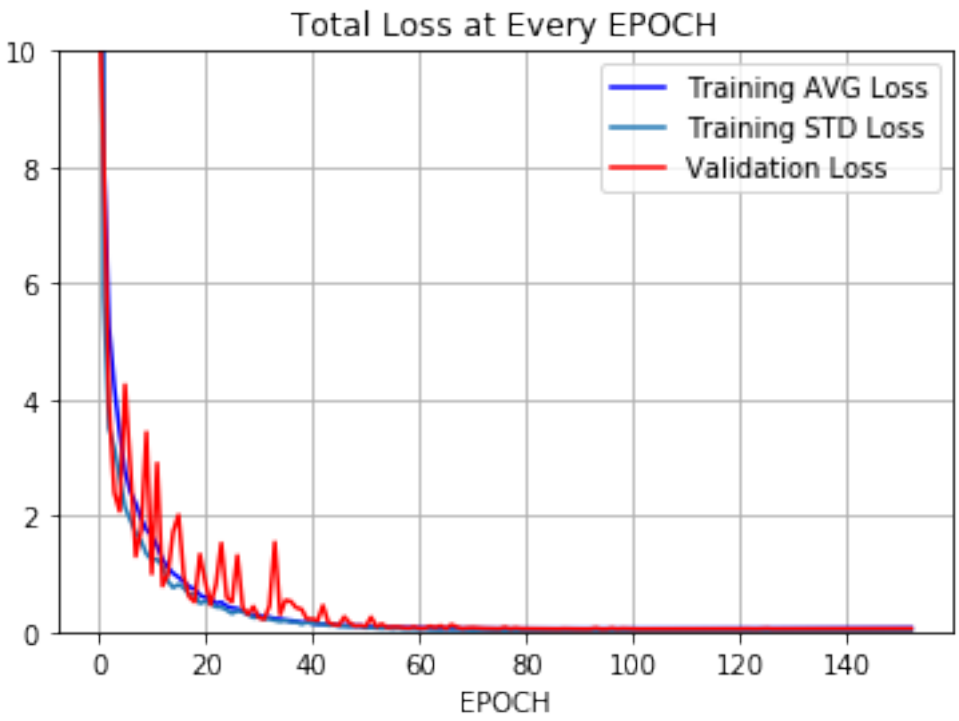
[EPOCH  150 ] LOSS     :(TRAIN) 0.0842194408        (TEST): 0.0548142642
                ACCURACY :(TRAIN) 88.7777777778%       (TEST): 88.8000000000%

[EPOCH  151 ] LOSS     :(TRAIN) 0.0597380549        (TEST): 0.0412292555
                ACCURACY :(TRAIN) 88.3333333333%       (TEST): 90.0000000000%

[EPOCH  152 ] LOSS     :(TRAIN) 0.0706750378        (TEST): 0.0390633158
                ACCURACY :(TRAIN) 90.1111111111%       (TEST): 90.0000000000%
```

[358]:
```
plt.plot(loss_train_mean,color="b",label='Training AVG Loss')
plt.plot(loss_train_std,label='Training STD Loss')
plt.plot(loss_test_mean,color="r",label='Validation Loss')
plt.legend(loc='upper right')
plt.ylim([0,10])
plt.grid()
plt.title("Total Loss at Every EPOCH")
plt.xlabel("EPOCH")
```

[358]:
```
Text(0.5, 0, 'EPOCH')
```

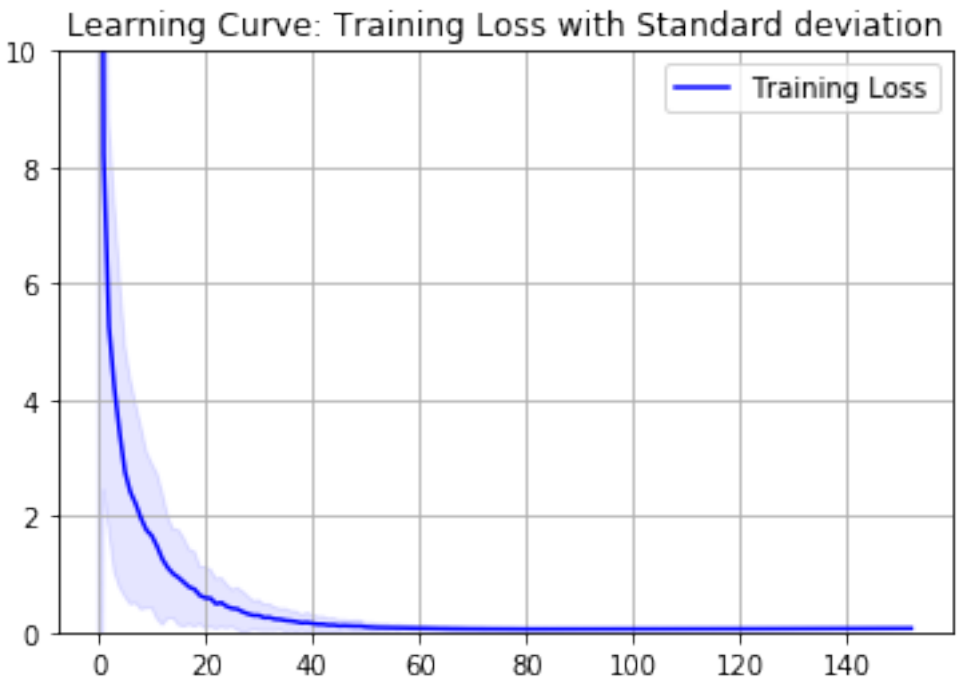


[359]:
```
from sklearn.naive_bayes import GaussianNB
from sklearn.model_selection import learning_curve
from sklearn.model_selection import ShuffleSplit
from sklearn.svm import SVC
from sklearn.datasets import load_digits


train_sizes=np.array(range(epochs))

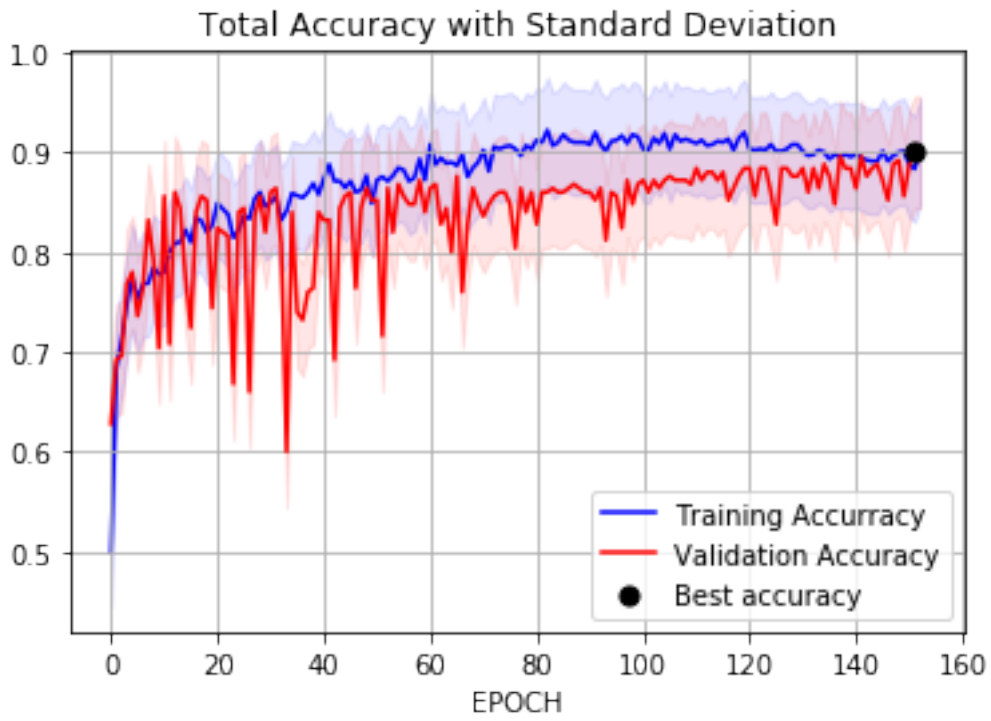

plt.title("Learning Curve: Training Loss with Standard deviation")
plt.grid()
plt.ylim([0,10])
plt.fill_between(train_sizes,loss_train_mean  - loss_train_std, loss_train_mean␣
 ↪+ loss_train_std, alpha=0.1,color="b")
plt.plot(train_sizes, loss_train_mean, color="b",label="Training Loss")
plt.legend(loc='upper right')

plt.show()
```



[360]:
```
max_index=np.argmax(accuracy_test)
accuracy_train_std_=np.std(accuracy_train)
accuracy_test_std_=np.std(accuracy_test)
plt.fill_between(train_sizes,accuracy_train  -␣
 ↪accuracy_train_std_,accuracy_train  + accuracy_train_std_, alpha=0.
 ↪1,color="b")
plt.fill_between(train_sizes,accuracy_test  - accuracy_test_std_,accuracy_test ␣
 ↪+ accuracy_test_std_, alpha=0.1,color="r")
plt.plot(accuracy_train, color="b",zorder=1,label="Training Accurracy")
plt.plot(accuracy_test,color="r",zorder=2,label='Validation Accuracy')
plt.
 ↪scatter(max_index,accuracy_test[max_index],c='black',s=50,zorder=10,label='Best␣
 ↪accuracy')
plt.legend(loc='lower right')
plt.grid()
plt.title("Total Accuracy with Standard Deviation")
plt.xlabel("EPOCH")
```

[360]:
```
Text(0.5, 0, 'EPOCH')
```



[361]:
```
max_index=np.argmax(accuracy_test)
print("""
                            <At convergence>
+-----------------------------+-----------------------+--------------------+
|       At convergence        |          Loss         |      Accuracy      |
+-----------------------------+-----------------------+--------------------+
|       Training              |         %6.3f         |      %6.2f %%      |
+-----------------------------+-----------------------+--------------------+
|      Validation             |         %6.3f         |      %6.2f %%      |
+-----------------------------+-----------------------+--------------------+

""
%(loss_train_mean[epochs-1],accuracy_train[epochs-1]*100,loss_test_mean[epochs-1],accuracy_tes
```

```
                            <At convergence>
+-----------------------------+-----------------------+--------------------+
|       At convergence        |          Loss         |      Accuracy      |
+-----------------------------+-----------------------+--------------------+
|       Training              |          0.067        |       90.11 %      |
+-----------------------------+-----------------------+--------------------+
|      Validation             |          0.056        |       90.00 %      |
+-----------------------------+-----------------------+--------------------+
```

[ ]: