Simple Siamese Network Implementation

Implementation is done to get understanding of how contrastive learn work, which will help to implement FYP project

Dataset

Used AT&T Dataset

Can Be Found At : https://www.kaggle.com/datasets/kasikrit/att-database-of-faces

In [1]:
```
TRAINING_PATH = "att_data/training"
TESTING_PATH = "att_data/testing"
```

Configure and Import Required Libraries

In [2]:
```
%matplotlib inline
```

In [3]:
```
import os
import random
import torch
import numpy as np
import torch.nn as nn
import torchvision
import torchvision.transforms as transforms
from IPython.display import display
from PIL import Image
import matplotlib.pyplot as plt
import torch.nn.functional as F
```

Preparing Dataset

There are three persons in dataset. And each one containing 10 images. In order to train good neural network we need to precent class imbalance. Where we need to choose pair of images such that, 50% of images related to person and 50% images related to different person

Let's list all image paths and give tag

Train Dict

In [4]:
```
content_of_training_directory = os.listdir(TRAINING_PATH)
train_img_dict = []

for tag in content_of_training_directory:

    images_under_tag = os.listdir(TRAINING_PATH+"/"+tag)

    for image in images_under_tag:
```

```
        image_location = TRAINING_PATH+"/"+tag+"/"+image
        img = Image.open(image_location)

        img.convert("L")
        img.resize((100,100))

        transform = transforms.Compose([transforms.PILToTensor()])
        tensor = transform(img)
        train_img_dict.append((tensor, tag))

random.shuffle(train_img_dict)
train_img_dict[0]
```

Out[4]:
```
(tensor([[[104, 106, 107,  ...,  99, 100,  97],
          [106, 106, 102,  ...,  96, 100,  99],
          [105, 104, 104,  ..., 101,  95,  94],
          ...,
          [152, 107,  93,  ...,  59,  52,  42],
          [144,  83, 107,  ...,  72,  63,  67],
          [115,  84, 128,  ...,  65,  59,  73]]], dtype=torch.uint8),
 's38')
```

Test Dict

In [5]:
```
content_of_training_directory = os.listdir(TESTING_PATH)
test_img_dict = []

for tag in content_of_training_directory:

    images_under_tag = os.listdir(TESTING_PATH+"/"+tag)

    for image in images_under_tag:

        image_location = TESTING_PATH+"/"+tag+"/"+image
        img = Image.open(image_location)

        img.convert("L")
        img.resize((100,100))

        transform = transforms.Compose([transforms.PILToTensor()])
        tensor = transform(img)
        test_img_dict.append((tensor, tag))

random.shuffle(test_img_dict)
test_img_dict[0]
```

Out[5]:
```
(tensor([[[157, 152, 154,  ..., 152, 150, 151],
          [155, 152, 156,  ..., 151, 151, 150],
          [153, 153, 154,  ..., 152, 150, 151],
          ...,
          [105, 104, 115,  ..., 111, 113, 110],
          [115, 122, 146,  ..., 109, 113, 110],
          [135, 144, 157,  ..., 111, 108, 109]]], dtype=torch.uint8),
 's6')
```

Image Dict Contain Images And Tag as (PIL_IMAGE, TAG)

Now we need to make a batch with 50% similarity

In [6]:
```
def load_a_batch(batchsize,img_dict):

    # Content -> List Of (Image_1_Tensor, Image_2_Tensor, Is_Similar_Boolean)
    output_list = []

    # Select Similar Images
    for i in range(batchsize//2):
        img_1 = random.choice(img_dict)
        while True:
            img_2 = random.choice(img_dict)
            if img_1[1]==img_2[1]:
                output_list.append((img_1[0],img_2[0],True))
                break

    # Select Dissimilar Images
    for i in range(batchsize//2,batchsize):
        img_1 = random.choice(img_dict)
        while True:
            img_2 = random.choice(img_dict)
            if img_1[1]!=img_2[1]:
                output_list.append((img_1[0],img_2[0],False))
                break

    # Shuffle
    random.shuffle(output_list)

    # Return
    return output_list
```

We need a function to view a batch

In [7]:
```
def batch_image(batch):
    list_of_vertical_joined = []
    is_similar = []
    for i in range(len(batch)):
        res = torch.cat((torch.squeeze(batch[i][0]), torch.squeeze(batch[i][1])), 0)
        list_of_vertical_joined.append(res)
        is_similar.append(batch[i][2])
    res = list_of_vertical_joined[0]
    for i in range(1,len(list_of_vertical_joined)):
        res = torch.cat((res, list_of_vertical_joined[i]), 1)
    return transforms.ToPILImage()(res),is_similar
```

In [8]:
```
batch1 = load_a_batch(10,train_img_dict)
img,is_similar = batch_image(batch1)
print(is_similar)
img
```

```
[False, False, True, True, False, False, True, False, True, True]
```

Out[8]:

In [9]:
```
def imshow(img, text=None):
    plt.axis("off")
    if text:
        plt.text(75, 8, text, style='italic',fontweight='bold',
            bbox={'facecolor':'white', 'alpha':0.8, 'pad':10})

    plt.imshow(img)
    plt.show()
```

Build Model

Here is how Siamese Network defined

 SiaMese Network Architecture

In [10]:
```
class MySiameseNetwork(nn.Module):

    def __init__(self):
        super(MySiameseNetwork,self).__init__()

        self.cn_network = nn.Sequential(
            # Conv1
            nn.Conv2d(1,96,kernel_size =11, stride=4),
            nn.ReLU(),
            nn.MaxPool2d(3,stride=2),

            # Conv2
            nn.Conv2d(96,256,kernel_size =5, stride=1),
            nn.ReLU(),
            nn.MaxPool2d(2,stride=2),

            # Conv3
            nn.Conv2d(256,384,kernel_size =3, stride=1),
            nn.ReLU(),
        )

        self.fc_network = nn.Sequential(
            # FC 1
            nn.Linear(768,1024),
            # FC 2
            nn.Linear(1024,256),
            # FC 2
            nn.Linear(256,2)
        )
```

```
    def SendThroughNetwork(self,image):
        out_cn = self.cn_network(image)
        shape = out_cn.shape
        flatten_out = out_cn.view(shape[0],-1)
        output = self.fc_network(flatten_out)
        return output

    def GetInputsAndLabels(self,batch):
        image_1_list=[]
        image_2_list=[]
        labels = []

        for img1,img2,label in batch:
            image_1_list.append(torch.unsqueeze(img1,0))
            image_2_list.append(torch.unsqueeze(img2,0))
            labels.append(torch.unsqueeze(torch.tensor(int(label)),0))

        return torch.cat(image_1_list,dim=0).float(),torch.cat(image_2_list,dim=0).flo

    def forward(self,image_1,image_2):

        # Send Two Images Through Same Network
        output1 = self.SendThroughNetwork(image_1)
        output2 = self.SendThroughNetwork(image_2)

        return output1,output2
```

In [11]:
```
siamese_network = MySiameseNetwork()
image_1_batch,image_2_batch,labels_batch =siamese_network.GetInputsAndLabels(batch1)
```

In [12]:
```
image_2_batch.shape
```

Out[12]:
```
torch.Size([10, 1, 112, 92])
```

In [13]:
```
x1,x2 = siamese_network(image_1_batch,image_2_batch)
```

Define Loss

In [14]:
```
def ContastiveLoss(x1, x2, label, margin: float = 1.0):

    dist = torch.nn.functional.pairwise_distance(x1, x2)

    loss = (1 - label) * torch.pow(dist, 2) \
        + (label) * torch.pow(torch.clamp(margin - dist, min=0.0), 2)
    loss = torch.mean(loss)

    return loss
```

In [15]:
```
ContastiveLoss(x1,x2,labels_batch)
```

Out[15]:
```
tensor(0.4087, grad_fn=<MeanBackward0>)
```

Function To Stack Batch

In [16]:
```
def stack(batch):
    img_1 = batch[0][0].unsqueeze(0).float()
    img_2 = batch[0][1].unsqueeze(0).float()
    labels = []
    for i in range(1,len(batch)):
        next_img = batch[i][0].unsqueeze(0)
        img_1 = torch.cat([img_1,next_img],dim=0).float()
    for i in range(1,len(batch)):
        next_img = batch[i][1].unsqueeze(0)
        img_2 = torch.cat([img_2,next_img],dim=0).float()
    for i in range(len(batch)):
        labels.append(torch.unsqueeze(torch.tensor(int(batch[i][2])),0).float())

    labels = torch.cat(labels, dim=0).float()

    return img_1,img_2,labels
```

Create Train Dataset

In [17]:
```
train_dataset = []
no_of_batches = 20
batch_size = 50

for i in range(no_of_batches):
    batch = load_a_batch(batch_size,train_img_dict)
    train_dataset.append(stack(batch))
```

Create Validation Dataset

In [18]:
```
validation_dataset = []
no_of_batches = 10
batch_size = 30

for i in range(no_of_batches):
    batch = load_a_batch(batch_size,test_img_dict)
    validation_dataset.append(stack(batch))
```

Train Model

In [19]:
```
neural_network = MySiameseNetwork()
loss_func = ContastiveLoss
opt = torch.optim.Adam(neural_network.parameters(), lr = 0.0005)
```

In [20]:
```
counter = []
train_history = []
val_history = []
iter_no    = 0
```

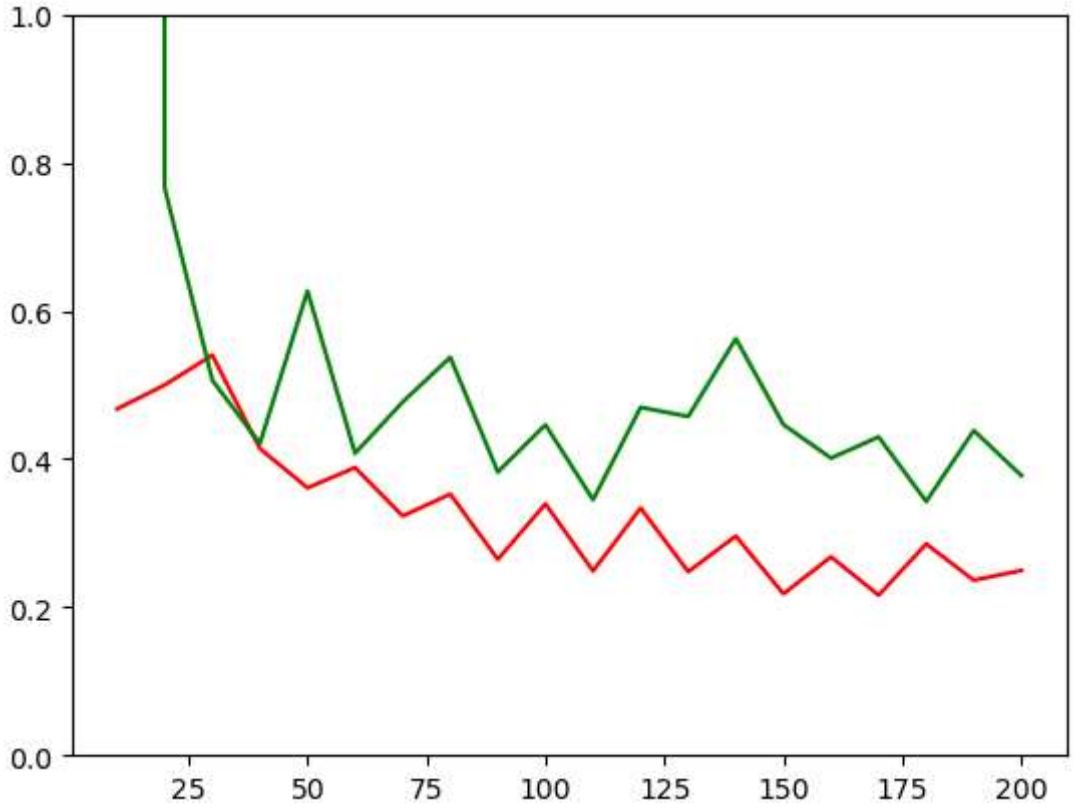
In [21]:
```
for epoch in range(10):
    i = 0
    for img_1,img_2,label in train_dataset:

        # Zero The Grads
        opt.zero_grad()
```

```
        # Get Outputs
        out1,out2 = neural_network(img_1,img_2)

        # Calc Loss
        loss = loss_func(out1,out2,label)

        # Calc Gradients
        loss.backward()

        # Update Weights
        opt.step()


        # Every 10 batch print result
        if i%10 ==0:
            val_loss = []
            for img_1,img_2,label in validation_dataset:

                # Get Outputs
                out1,out2 = neural_network(img_1,img_2)

                # Calc Loss
                val_loss.append(loss_func(out1,out2,label).item())

            val_loss_mean = sum(val_loss) / len(val_loss)
            print("Epoch No :",epoch,"iter :",i,"Current Loss:",loss.item(),"Validatic
            iter_no+=10
            counter.append(iter_no)
            train_history.append(loss.item())
            val_history.append(val_loss_mean)
        i+=1
```

```
Epoch No : 0 iter : 0 Current Loss: 0.46750205755233765 Validation Loss :  90.5003498
0773925
Epoch No : 0 iter : 10 Current Loss: 0.4998623728752136 Validation Loss :  0.76573940
51551819
Epoch No : 1 iter : 0 Current Loss: 0.540237545967102 Validation Loss :  0.5063556820
15419
Epoch No : 1 iter : 10 Current Loss: 0.41419804096221924 Validation Loss :  0.4210254
728794098
Epoch No : 2 iter : 0 Current Loss: 0.3610725402832031 Validation Loss :  0.626714515
6860352
Epoch No : 2 iter : 10 Current Loss: 0.3883932828903198 Validation Loss :  0.40769400
596618655
Epoch No : 3 iter : 0 Current Loss: 0.3231580853462219 Validation Loss :  0.476996386
051178
Epoch No : 3 iter : 10 Current Loss: 0.3525652587413788 Validation Loss :  0.53730750
08392334
Epoch No : 4 iter : 0 Current Loss: 0.26461148262023926 Validation Loss :  0.38243002
29549408
Epoch No : 4 iter : 10 Current Loss: 0.3393959105014801 Validation Loss :  0.44616625
010967254
Epoch No : 5 iter : 0 Current Loss: 0.2489050328731537 Validation Loss :  0.345054286
7183685
Epoch No : 5 iter : 10 Current Loss: 0.33381229639053345 Validation Loss :  0.4697569
9365139006
Epoch No : 6 iter : 0 Current Loss: 0.24788039922714233 Validation Loss :  0.45740190
74440002
Epoch No : 6 iter : 10 Current Loss: 0.2960507571697235 Validation Loss :  0.56251985
13269425
Epoch No : 7 iter : 0 Current Loss: 0.21804244816303253 Validation Loss :  0.44637202
62050629
Epoch No : 7 iter : 10 Current Loss: 0.268040269613266 Validation Loss :  0.401092442
87014006
Epoch No : 8 iter : 0 Current Loss: 0.2162335366010666 Validation Loss :  0.429836517
57240293
Epoch No : 8 iter : 10 Current Loss: 0.28532618284225464 Validation Loss :  0.3426893
472671509
Epoch No : 9 iter : 0 Current Loss: 0.23643992841243744 Validation Loss :  0.43834664
82162476
Epoch No : 9 iter : 10 Current Loss: 0.24966217577457428 Validation Loss :  0.3776511
371135712
```

In [26]:

```
plt.plot(counter, train_history, color='r', label='Train')
plt.plot(counter, val_history, color='g', label='Validation')
plt.ylim(0, 1)
plt.show()
```



In [25]:
```
train_history
```

Out[25]:
```
[0.46750205755233765,
 0.4998623728752136,
 0.540237545967102,
 0.41419804096221924,
 0.3610725402832031,
 0.3883932828903198,
 0.3231580853462219,
 0.3525652587413788,
 0.26461148262023926,
 0.3393959105014801,
 0.2489050328731537,
 0.33381229639053345,
 0.24788039922714233,
 0.2960507571697235,
 0.21804244816303253,
 0.268040269613266,
 0.2162335366010666,
 0.28532618284225464,
 0.23643992841243744,
 0.24966217577457428]
```

In [27]:
```
test_batch = load_a_batch(10,test_img_dict)
img_1,img_2,label = stack(test_batch)
out1,out2 = neural_network(img_1,img_2)
dist = list(F.pairwise_distance(out1,out2))

for i in range(len(test_batch)):

    res = torch.cat((img_1[i].squeeze(), img_2[i].squeeze()), 1).float()
    pil_img = transforms.ToPILImage()(res)
```

```
    text = f"Similar : {bool(label[i].item())} , Dissimilarity : {round(dist[i].item()
    imshow(res,text)
```


Similar : True , Dissimilarity : 0.04


Similar : True , Dissimilarity : 0.13


Similar : True , Dissimilarity : 0.17


Similar : False , Dissimilarity : 0.18


Similar : True , Dissimilarity : 0.0


Similar : False , Dissimilarity : 0.6

In [24]:
```
test_batch[0]
```

Out[24]:
```
(tensor([[[128, 125, 126,  ..., 125, 126, 123],
          [127, 127, 124,  ..., 124, 124, 124],
          [127, 127, 124,  ..., 125, 124, 127],
          ...,
          [ 87, 102,  94,  ...,  87,  86,  87],
          [103, 105,  92,  ...,  88,  83,  87],
          [ 92,  92,  89,  ...,  84,  85,  85]]], dtype=torch.uint8),
 tensor([[[126, 127, 126,  ..., 125, 126, 125],
          [126, 129, 126,  ..., 125, 127, 125],
          [128, 124, 129,  ..., 124, 126, 124],
          ...,
          [ 86,  89,  91,  ...,  87,  87,  86],
          [101,  98,  97,  ...,  86,  86,  86],
          [100,  98,  99,  ...,  87,  85,  89]]], dtype=torch.uint8),
 True)
```

In [ ]: