ex10_2

July 13, 2019

In [3]:
```
from sklearn.manifold import TSNE
from sklearn.cluster import KMeans
import numpy as np
import matplotlib.pyplot as plt
import torch.nn as nn
import torch
from torch.nn import functional as F
from torch.autograd import Variable
from torch.utils.data import DataLoader
from torchvision import datasets

import torch.distributions as tdist
import torchvision.transforms as transforms


class Variational_Autoencoder(nn.Module):

    def __init__(self, input_shape=(28, 28, 1)):
        super(Variational_Autoencoder, self).__init__()
        self.training = True
        ndist = tdist.Normal(torch.tensor([4.0]), torch.tensor([0.5]))
        self.encoder = nn.Sequential(
            nn.Linear(input_shape[0]*input_shape[1]*input_shape[2], 512),
            nn.ReLU(),
            nn.Linear(512, 256),
            nn.ReLU(),
            nn.Linear(256, 64)
        )

        self.decoder = nn.Sequential(
            nn.Linear(64, 256),
            nn.ReLU(),
            nn.Linear(256, 512),
            nn.ReLU(),
            nn.Linear(512, input_shape[0]*input_shape[1]*input_shape[2]),
            nn.Tanh()
        )
```

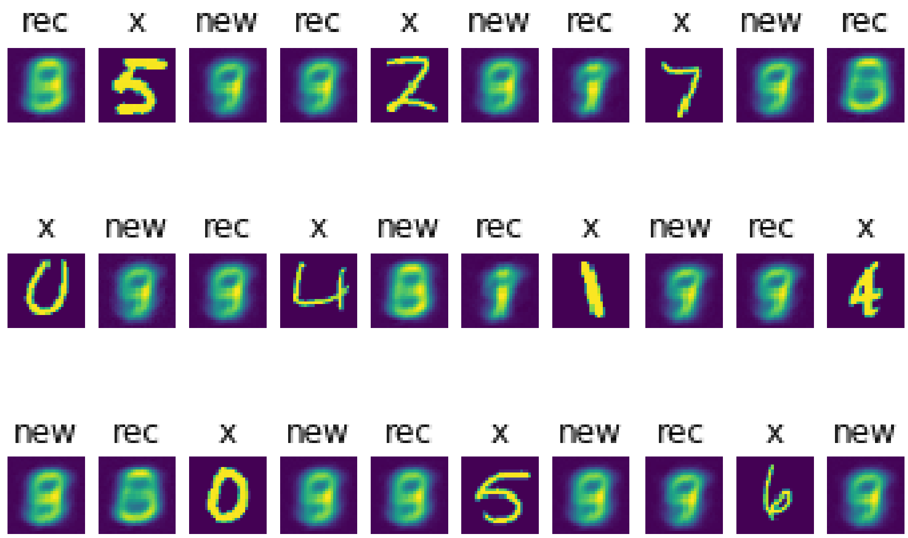
```
    def forward(self, x=None, decode=None):
        if decode is None:
            flat = torch.flatten(x, start_dim=2)
            features = self.encoder(flat)

            # get mean and std-dev
            mu = torch.mean(features, dim=2)
            sig = torch.std(features, dim=2)
            # make sure bit have the same numer of elements as out
            sigmas = torch.ones((features.shape[0], features.shape[2]))*sig
            means = torch.ones((features.shape[0], features.shape[2]))*mu

            dist = reparameterize(self, means, sigmas)

            out = self.decoder(dist)

            return out, means, sigmas, features
        return self.decoder(decode)

# Manifold approximation using tSNE
#
# features: (numpy array) N x D feature matrix
# images: (numpy array) N x H x W x 3
# path_save: string (path where you want to save the final image)
def apply_tnse_img(features, images, path_save='./tsne_img.png'):

    tnse = TSNE(n_components=2, init='pca', n_iter=1000, random_state=1254, perplexity=
    # np.set_printoptions(False)
    vis_data = tnse.fit_transform(features)
    vis_x = vis_data[:, 0]
    vis_y = vis_data[:, 1]

    # get max heigth, width
    max_width = max([image.shape[0] for image in images])
    max_height = max([image.shape[1] for image in images])

    # get max, min coords
    x_min, x_max = vis_x.min(), vis_x.max()
    y_min, y_max = vis_y.min(), vis_y.max()

    # Fix the ratios
    res = 700
    sx = (x_max - x_min)
    sy = (y_max - y_min)
    if sx > sy:
        res_x = int(sx / float(sy) * res)
        res_y = res
    else:
```

```
            res_x = res
            res_y = int(sy / float(sx) * res)

        # impaint images
        canvas = np.ones((res_x + max_width, res_y + max_height, 3))
        x_coords = np.linspace(x_min, x_max, res_x)
        y_coords = np.linspace(y_min, y_max, res_y)
        for x, y, image in zip(vis_x, vis_y, images):
            w, h = image.shape[:2]
            x_idx = np.argmin((x - x_coords) ** 2)
            y_idx = np.argmin((y - y_coords) ** 2)
            try:
                canvas[x_idx:x_idx + w, y_idx:y_idx + h] = image
            except:
                print('Image out of borders.... skip!')

        # plot image
        fig = plt.figure()
        plt.imshow(canvas)

        mng = plt.get_current_fig_manager()
        mng.full_screen_toggle()
        plt.show()
        plt.pause(3)
        fig.savefig(path_save, bbox_inches='tight')

    # Reparametrization trick for training VAEs
    #
    # mu and logvar: output of your encoder
    def reparameterize(self, mu, logvar):
        if self.training:
            std = logvar.mul(0.5).exp_()
            eps = Variable(std.data.new(std.size()).normal_())
            return eps.mul(std).add_(mu)
        else:
            return mu

    # VAE Loss
    #
    # recon_x: image reconstructions
    # x: images
    # mu and logvar: outputs of your encoder
    # batch_size: batch_size
    # img_size: width, respectively height of you images
    # nc: number of image channels
    def loss_function(recon_x, x, mu, logvar, batch_size, img_size, nc):
        MSE = F.mse_loss(recon_x, x.view(-1, img_size * img_size * nc))
```

```
    # 0.5 * sum(1 + log(sigma^2) - mu^2 - sigma^2)
    KLD = -0.5 * torch.sum(1 + logvar - mu.pow(2) - logvar.exp())

    # Normalize
    KLD /= batch_size * img_size * img_size * nc

    return MSE + KLD

def train(trainloader, model, batchsize, use_gpu=False, lr=0.001, num_epochs = 10):
    model.train()
    optimizer = torch.optim.Adam(model.parameters(), lr=lr)

    if use_gpu:
        model.cuda()

    for epoch in range(num_epochs):
        for step, (x, label) in enumerate(trainloader):
            if use_gpu:
                x = x.cuda()
            optimizer.zero_grad()
            recon_x, mu, sigma, features = model(x=x)
            loss = loss_function(recon_x, x, mu, sigma, batchsize, 28, 1)
            loss.backward()
            optimizer.step()

            if epoch == 1 or epoch == 5:
                if step == 0:
                    means = torch.zeros((10, 64))
                    sigmas = torch.ones((10, 64))
                    newCode = torch.normal(means, sigmas)
                    newImg = model(decode=newCode)
                    plt.figure()
                    for i in range(10):
                        plt.subplot(3, 10, i*3 + 1)
                        plt.imshow(recon_x[i].view(28, 28).detach().numpy());plt.title
                        plt.subplot(3, 10, i * 3 + 2)
                        plt.imshow(x[i].view(28, 28).detach().numpy());plt.title('x');p
                        plt.subplot(3, 10, i * 3 + 3)
                        plt.imshow(newImg[i].view(28, 28).detach().numpy());plt.title(
                    plt.show()

    means = torch.zeros((10, 64))
    sigmas = torch.ones((10, 64))
    newCode = torch.normal(means, sigmas)
    newImg = model(decode=newCode)
    plt.figure()
    for i in range(10):
        plt.subplot(3, 10, i * 3 + 1)
```

```
            plt.imshow(recon_x[i].view(28, 28).detach().numpy());plt.title('rec');plt.axis
            plt.subplot(3, 10, i * 3 + 2)
            plt.imshow(x[i].view(28, 28).detach().numpy());plt.title('x');plt.axis('off')
            plt.subplot(3, 10, i * 3 + 3)
            plt.imshow(newImg[i].view(28, 28).detach().numpy());plt.title('new');plt.axis(
        plt.show()

    def visualizeDataManifold(loader, model, batchsize, use_gpu=False):
        model.eval()
        if use_gpu:
            model.cuda()

        for x, label in loader:
            break;
        if use_gpu:
            x = x.cuda()
        recon_x, mu, sig, features = model(x=x)
        flat = torch.flatten(x, start_dim=2)
        flat = flat.squeeze(1)
        kmeans = KMeans(n_clusters=10).fit(flat.detach().numpy())
        pred = kmeans.predict(flat.detach().numpy())
        apply_tnse_img(features.squeeze(1).detach().numpy(), x.squeeze(1).detach().numpy()

    if __name__ == '__main__':
        load = False
        tr = True
        evl = True
        model = Variational_Autoencoder()

        if load:
            model.load_state_dict(torch.load('./s_dict2.pt'))

        if tr:
            transform = transforms.ToTensor()
            trainset = datasets.MNIST('.', transform=transform)
            trainloader = torch.utils.data.DataLoader(trainset, batch_size=128, pin_memory=
            train(trainloader, model, 128)

            torch.save(model.state_dict(), './s_dict2.pt')

        if evl:
            transform = transforms.ToTensor()
            dset = datasets.MNIST('.', transform=transform)
            loader = torch.utils.data.DataLoader(dset, batch_size=400, pin_memory=True, nu
            visualizeDataManifold(loader, model, 400)
```


rec x new rec x new rec x new rec
x new rec x new rec x new rec x
new rec x new rec x new rec x new
rec x new rec x new rec x new rec
x new rec x new rec x new rec x
new rec x new rec x new rec x new




```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

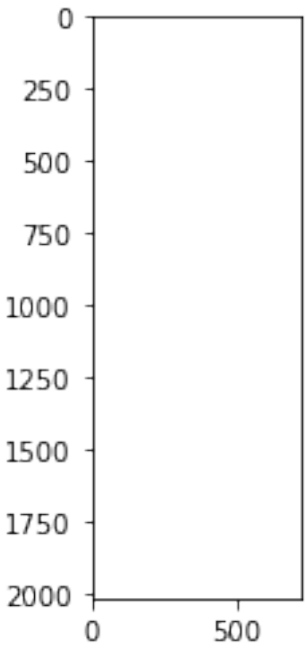
```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```

```
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
Image out of borders... skip!
```



Comments: I think the image was to large to be visualized. At least thats wat the warnings said. I guess that the result is, that on the 2D plane most features map to one of the 10 image classes.