symmetric_vae

April 25, 2019

1 Symmetric VAE - pytorch

This is the implementation for AISTATS 2018 paper:
Symmetric Variational Autoencoder and Connections to Adversarial Learning
Code adapted from: https://github.com/LiqunChen0606/Symmetric-VAE

```
In [0]: from google.colab import drive
        drive.mount('/content/drive')


        %cd /content/drive/My\ Drive/Masters-DS/CSCI-B659/project/symmetric-vae
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/con
```

1.1 Import Libraries

```
In [0]: from glob import glob
        import os
        import numpy as np
        import matplotlib.pyplot as plt
        import shutil
        from torchvision import transforms
        from torchvision import models
        import torchvision
        import torch
        from torch.autograd import Variable
        import torch.nn as nn
        from torch.optim import lr_scheduler
        from torch import optim
        from torchvision.datasets import ImageFolder
        from torchvision.utils import make_grid
        import time
        from torchvision import datasets,transforms
        import torch.nn.functional as F
        import torch.optim as optim
import os
from torchvision.utils import save_image
#import torchnet as tnt

## Plotting library
from matplotlib.offsetbox import OffsetImage, AnnotationBbox
from matplotlib.backends.backend_agg import FigureCanvasAgg as FigureCanvas
import matplotlib.gridspec as gridspec
import cv2
from scipy.stats import norm
from sklearn import manifold

plt.style.use('seaborn')
%matplotlib inline

print('Torch', torch.__version__, 'CUDA', torch.version.cuda)
print('Device:', torch.device('cuda:0'))
print(torch.cuda.is_available())

is_cuda = torch.cuda.is_available()
device = torch.device ( "cuda:0" if torch.cuda.is_available () else "cpu" )
```

```
Torch 1.0.1.post2 CUDA 10.0.130
Device: cuda:0
True
```

```
In [0]: %pwd
```

```
Out[0]: '/content/drive/My Drive/Masters-DS/CSCI-B659/project/symmetric-vae'
```

1.2 Plotting Libraries

```
In [0]: ## Show image
        def imshow(img,title=None):
          """Imshow for Tensor."""
          img = img.numpy().transpose((1,2,0))
          mean = np.array([0.485, 0.456, 0.406])
          std = np.array([0.229, 0.224, 0.225])
          img = std * img + mean # normalize
          img = np.clip(img, 0, 1) # clip image
          plt.figure(figsize=(16,4))
          plt.axis('off')
          plt.imshow(img)

          if title is not None:
            plt.title(title)
```

```
def plot_grid(inputs):
  # Make a grid from batch
  out = torchvision.utils.make_grid(inputs,10,10)
  imshow(out, title="")

## Visualize some images in the dataset
def visualizeDataset(X):
  for i,image in enumerate(X):
    cv2.imshow(str(i),image)
    cv2.waitKey()
    cv2.destroyAllWindows()

def plot_loss(y, title):
  plt.figure()
  plt.plot(y)
  plt.title(title)
  plt.xlabel('epochs')
  plt.ylabel('Loss')

def plot_accuracy(y, title):
  plt.figure()
  plt.plot(y)
  plt.title(title)
  plt.xlabel('epochs')
  plt.ylabel('accuracy')


## Scatter Plot
def scatterplot(x, y, ax, imageData, zoom):
  images = []
  imageSize = 28
  for i in range(len(x)):
    x0, y0 = x[i], y[i]

    # Convert to image
    img = imageData[i]*255.
    img = (img).numpy()
    img = img.astype(np.uint8).reshape([imageSize,imageSize])
    img = cv2.cvtColor(img,cv2.COLOR_GRAY2RGB)

    # Note: OpenCV uses BGR and plt uses RGB
    image = OffsetImage(img, zoom=zoom)
    ab = AnnotationBbox(image, (x0, y0), xycoords='data', frameon=False)
    images.append(ax.add_artist(ab))

  ax.update_datalim(np.column_stack([x, y]))
  ax.autoscale()
```

```
import seaborn as sns
palette = np.array(sns.color_palette("hls", 10))

def plot_scatter(projection,labels):
    plt.scatter(projection[:,0], projection[:,1],c=[palette[i] for i in labels])



# Show dataset images with T-sne projection of pixel space
def tsne_projection_latent_space(X, image_size, display=True):
    # Compute t-SNE embedding of latent space


    tsne = manifold.TSNE(n_components=2, init='pca', random_state=0)
    X_tsne = tsne.fit_transform(X.reshape([-1,image_size*image_size*1]))

    # Plot images according to t-sne embedding
    if display:

        fig, ax = plt.subplots()
        scatterplot(X_tsne[:, 0], X_tsne[:, 1], imageData=X, ax=ax, zoom=0.6)
        plt.show()
    else:
        return X_tsne


# Show dataset images with T-sne projection of pixel space
def tsne_projection_latent_space2(X, Y, image_size, display=True):
    # Compute t-SNE embedding of latent space

    print("tsne projection of latent space...")
    tsne = manifold.TSNE(n_components=2, init='pca', random_state=0)
    X_tsne = tsne.fit_transform(X.reshape([-1,image_size*image_size*1]))

    # Plot images according to t-sne embedding
    if display:
        print("Plotting t-SNE visualization...")
        fig, ax = plt.subplots()
        plot_scatter(X_tsne, Y)
        plt.show


    else:
        return X_tsne

#os.makedirs("./logs")
%ls
```

```
cifar_h5  data/  logs/  model/  url.txt  visdomlog.txt
```

1.3 TensorBoard Utilities

```
In [0]: import tensorflow as tf
        import numpy as np
        import scipy.misc
        from PIL import Image
        try:
            from StringIO import StringIO  # Python 2.7
        except ImportError:
            from io import BytesIO         # Python 3.x

        ## Import tensor flow library
        class TensorBoardLogger(object):

          """
          Initialize the summary writer
          """
          def __init__(self, log_dir):
            "create summary writer"
            self.writer = tf.summary.FileWriter(log_dir)

          """
          Add scalar
          """
          def scalar_summary(self, tag, value, step):
            summary = tf.Summary(value=[tf.Summary.Value(tag=tag, simple_value=value)])
            self.writer.add_summary(summary,step)

          """
          Add images
          """
          def image_summary(self, tag, images, step):
            """Log a list of images."""

            img_summaries = []
            for i, img in enumerate(images):
                s = BytesIO()

                new_p = Image.fromarray(img)
                if new_p.mode != 'L':
                  new_p = new_p.convert('L')

                new_p.save(s, format="png")

                # Create an Image object
        img_sum = tf.Summary.Image(encoded_image_string=s.getvalue(),
                                   height=img.shape[0],
                                   width=img.shape[1])
        # Create a Summary value
        img_summaries.append(tf.Summary.Value(tag='%s/%d' % (tag, i), image=img_sum))

    # Create and write Summary
    summary = tf.Summary(value=img_summaries)
    self.writer.add_summary(summary, step)

  def histo_summary(self, tag, values, step, bins=1000):
      """Log a histogram of the tensor of values."""

      # Create a histogram using numpy
      counts, bin_edges = np.histogram(values, bins=bins)

      # Fill the fields of the histogram proto
      hist = tf.HistogramProto()
      hist.min = float(np.min(values))
      hist.max = float(np.max(values))
      hist.num = int(np.prod(values.shape))
      hist.sum = float(np.sum(values))
      hist.sum_squares = float(np.sum(values**2))

      # Drop the start of the first bin
      bin_edges = bin_edges[1:]

      # Add bin edges and counts
      for edge in bin_edges:
          hist.bucket_limit.append(edge)
      for c in counts:
          hist.bucket.append(c)

      # Create and write Summary
      summary = tf.Summary(value=[tf.Summary.Value(tag=tag, histo=hist)])
      self.writer.add_summary(summary, step)
      self.writer.flush()
```

```
import os

def make_dirs(dirname):
  if not os.path.exists(dirname):
    os.makedirs(dirname)
```

```
#make_dirs("logs")
```

```
        %ls

        ## Logging
        LOG_DIR = './logs'
        get_ipython().system_raw(
            'tensorboard --logdir {} --host 0.0.0.0 --port 6006 &'
            .format(LOG_DIR)
        )

        ! wget https://bin.equinox.io/c/4VmDzA7iaHb/ngrok-stable-linux-amd64.zip
        ! unzip ngrok-stable-linux-amd64.zip
        get_ipython().system_raw('./ngrok http 6006 &')
        ! curl -s http://localhost:4040/api/tunnels | python3 -c \
            "import sys, json; print(json.load(sys.stdin)['tunnels'][0]['public_url'])"
```

```
cifar_h5  data/  logs/  model/  url.txt  visdomlog.txt
--2019-04-19 21:35:53--  https://bin.equinox.io/c/4VmDzA7iaHb/ngrok-stable-linux-amd64.zip
Resolving bin.equinox.io (bin.equinox.io)... 52.200.123.104, 52.73.9.93, 52.21.103.149, ...
Connecting to bin.equinox.io (bin.equinox.io)|52.200.123.104|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 14977695 (14M) [application/octet-stream]
Saving to: ngrok-stable-linux-amd64.zip

ngrok-stable-linux- 100%[===================>]  14.28M  38.2MB/s    in 0.4s

2019-04-19 21:35:53 (38.2 MB/s) - ngrok-stable-linux-amd64.zip saved [14977695/14977695]

Archive:  ngrok-stable-linux-amd64.zip
  inflating: ngrok
http://70a5934e.ngrok.io
```

1.4 Params

```
In [0]: class Params:
          n_epochs = 101 ## number of epochs
          mb_size = 64 ## mini batch size
          lr = 1e-4 ## learning rate
          Z_dim = 128 * 2
          pa, pb = 0., 0.
          lamb = 1.


        torch.manual_seed(5)

Out[0]: <torch._C.Generator at 0x7fcc9c5e2eb0>
```

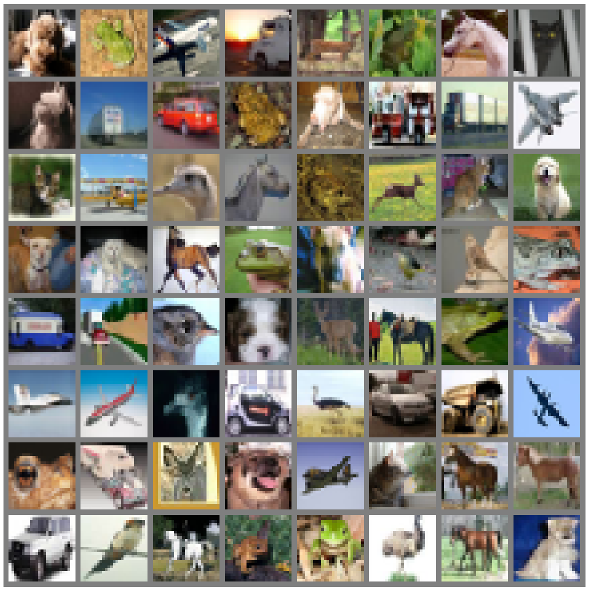
```
In [0]: def log(x):
            return torch.log(x + 1e-8)
```

1.5 Data Loader

```
In [0]: transform = transforms.Compose(
            [transforms.ToTensor(),
             transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))])

        trainset = torchvision.datasets.CIFAR10(root='./data', train=True,
                                                download=True, transform=transform)
        trainloader = torch.utils.data.DataLoader(trainset, batch_size=Params.mb_size,
                                                  shuffle=True, num_workers=2)
```

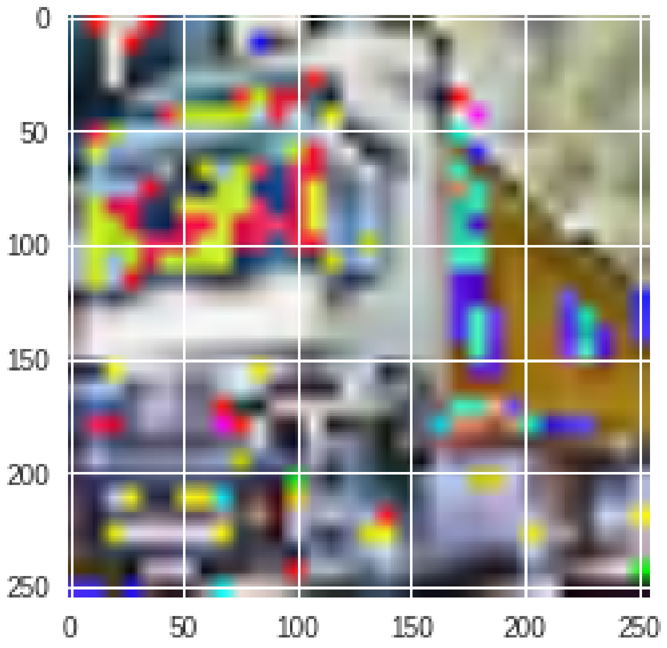
```
Files already downloaded and verified
```

```
In [0]: classes = ('plane', 'car', 'bird', 'cat',
                   'deer', 'dog', 'frog', 'horse', 'ship', 'truck')


        def imshow(img):
            img = img / 2 + 0.5     # unnormalize
            npimg = img.numpy()
            plt.imshow(np.transpose(npimg, (1, 2, 0)))
            plt.axis("off")
            plt.show()


        # get some random training images
        dataiter = iter(trainloader)
        images, labels = dataiter.next()

        # show images
        imshow(torchvision.utils.make_grid(images))
        # print labels
        print(' '.join('%5s' % classes[labels[j]] for j in range(4)))
```



```
  dog   frog plane truck
```

```
In [0]: ## print number of training examples
        num_train = len(trainset)
        test_image = trainset[1][0]
        %matplotlib inline
        def show(img):
            npimg = img.numpy()
            plt.imshow(np.transpose(npimg, (1,2,0)), interpolation='nearest')

        img2 = transforms.Compose([
            transforms.ToPILImage(),
            transforms.Resize(255),
            transforms.ToTensor(),
        ])(test_image)
        show(img2)
```



```
In [0]: t1,t2 = (next(iter(trainloader)))
        len(t1)

Out[0]: 64
```

1.6 Util Functions

```
In [0]: ## Sample from X and Y
        def sample_XY(X, Y, size):
            start_idx = np.random.randint(0, X.shape[0] - size)
            return X[start_idx:start_idx + size], Y[start_idx:start_idx + size]

        ## Sample from X
        def sample_X(X, size):
            start_idx = np.random.randint(0, X.shape[0] - size)
            return X[start_idx:start_idx + size]

        # Sample only from Y
        def sample_Y(Y, size):
            start_idx = np.random.randint(0, Y.shape[0] - size)
            return Y[start_idx:start_idx + size]

        ## Sample z
        def sample_Z(m, n):
            return np.array(np.random.uniform(-1., 1., size=[m, n]),dtype=np.float32)
```

####Test

```
In [0]: print("Sample z",sample_Z(3,3))
        print("Sample Y",sample_Y(np.arange(10),2))
        print("Sample X",sample_X(np.arange(10),2))
        print("Sample XY",sample_XY(np.arange(10),np.arange(20),4))
```

```
Sample z [[ 0.13984515  0.18054472  0.3723878 ]
 [-0.04984898 -0.07973368  0.67753357]
 [ 0.96554357 -0.298521    0.77980363]]
Sample Y [7 8]
Sample X [0 1]
Sample XY (array([5, 6, 7, 8]), array([5, 6, 7, 8]))
```

1.7 Plots

```
In [0]: def plot(samples,m = 8):
          fig = plt.figure(figsize= (m,m))
          gs = gridspec.GridSpec(m,m)
          gs.update(wspace = 0.05, hspace = 0.05)

          for i, sample in enumerate(samples):
            ax  = plt.subplot(gs[i])
            plt.axis("off")
            ax.set_xticklabels([])
            ax.set_yticklabels([])
            ax.set_aspect("equal")
            plt.imshow(sample)

          return fig


        #plot([trainset[i][0] for i in range(8)])
```

1.8 Models

1. Encoder 1
2. Encoder 2
3. Discriminator 1
4. Discriminator 2

1.8.1 Encoder1

```
In [0]: from torch.distributions import uniform

        """
        Initialize weights in pytorch
        """
```

```
def init_weights(m):
    if type(m) == nn.Linear or type(m) == nn.Conv2d:
        torch.nn.init.xavier_uniform_(m.weight)
        m.bias.data.fill_(0.01)

class Encoder1(nn.Module):
    def __init__(self, mb_size, hidden_dim):
        super(Encoder1, self).__init__()

        self.hidden_dim =  hidden_dim
        #16, 16, 32
        self.conv1 = nn.Conv2d(4, 32, kernel_size=5, stride=2, padding = 2)
        self.bn1 = nn.BatchNorm2d(32)


        self.conv2 = nn.Conv2d(32, 64, kernel_size=5, stride=2)
        self.bn2 = nn.BatchNorm2d(64)


        self.conv3 = nn.Conv2d(64, 128, kernel_size=5, stride=2,padding = 2)

        self.bn3 = nn.BatchNorm2d(128)

        self.conv4 = nn.Conv2d(128,256,kernel_size = 5, stride = 2, padding = 2)
        self.bn4 = nn.BatchNorm2d(256)

        self.fc = nn.Linear(256*2*2,self.hidden_dim)
        self.relu = nn.ReLU()


    def forward(self,x):

        distribution = uniform.Uniform(torch.Tensor([-1]),torch.Tensor([1]))
        noise = distribution.sample(torch.Size([x.size(0),1, 32,32]))
        noise = noise.squeeze(4)
        noise = noise.to(device)

        x = torch.cat([x,noise],dim = 1)
        x = self.relu(self.bn1(self.conv1(x)))

        x = self.relu(self.bn2(self.conv2(x)))
        x = self.relu(self.bn3(self.conv3(x)))
        x = self.relu(self.bn4(self.conv4(x)))

        ## Fully connected layers
        x = x.reshape(x.size(0), -1)
        x = torch.tanh(self.fc(x))
        return x
        Z_dim = 128*2
        encoder1 = Encoder1(Params.mb_size,Z_dim)
        encoder1.apply(init_weights)

        if is_cuda:
          encoder1 = encoder1.to(device)


        encoder1
```

```
Out[0]: Encoder1(
          (conv1): Conv2d(4, 32, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
          (bn1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True
          (conv2): Conv2d(32, 64, kernel_size=(5, 5), stride=(2, 2))
          (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True
          (conv3): Conv2d(64, 128, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
          (bn3): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_stats=Tru
          (conv4): Conv2d(128, 256, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
          (bn4): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=Tru
          (fc): Linear(in_features=1024, out_features=256, bias=True)
          (relu): ReLU()
        )
```

1.8.2 Encoder2

```
In [0]: # noise = tf.random_normal([mb_size, 10])
        def lrelu(x, leak=0.2, name="lrelu"):
              f1 = 0.5 * (1 + leak)
              f2 = 0.5 * (1 - leak)
              return f1 * x + f2 * abs(x)
        noise_dim = 20
        class Encoder2(nn.Module):

            def __init__(self, mb_size):
                super(Encoder2, self).__init__()

                self.fc  = nn.Linear(276, 64 * 8 * 4 * 4)
                self.bn = nn.BatchNorm1d(64 * 8 * 4 * 4)

                self.deconv1 = nn.ConvTranspose2d(8 * 64 , 64 * 4, 6, stride=2,padding = 2)
                self.bn1 = nn.BatchNorm2d(64 * 4)


                self.deconv2 = nn.ConvTranspose2d(64 * 4 , 64 * 2, 6, stride=2,padding = 2)
                self.bn2 = nn.BatchNorm2d(64 * 2)

                self.deconv3 = nn.ConvTranspose2d(64 * 2 , 3, 6, stride=2,padding = 2)
        self.lrelu = lrelu
        self.relu = F.relu

    def forward(self,x):
        distribution = uniform.Uniform(torch.Tensor([-1]),torch.Tensor([1]))
        noise = distribution.sample(torch.Size([x.size(0), 20])).squeeze()

        x = torch.cat([x, noise.to(device)],dim = 1)

        x = self.relu(self.bn(self.fc(x)))
        x = x.reshape([-1, 64 * 8, 4, 4])


        x = self.lrelu(self.bn1(self.deconv1(x)))

        x = self.relu(self.bn2(self.deconv2(x)))

        x = torch.tanh(self.deconv3(x))

        return x
```

```
In [0]: encoder2 = Encoder2(Params.mb_size)
        encoder2.apply(init_weights)
        if is_cuda:
          encoder2 = encoder2.to(device)

        print(encoder2)
```

```
Encoder2(
  (fc): Linear(in_features=276, out_features=8192, bias=True)
  (bn): BatchNorm1d(8192, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (deconv1): ConvTranspose2d(512, 256, kernel_size=(6, 6), stride=(2, 2), padding=(2, 2))
  (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (deconv2): ConvTranspose2d(256, 128, kernel_size=(6, 6), stride=(2, 2), padding=(2, 2))
  (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (deconv3): ConvTranspose2d(128, 3, kernel_size=(6, 6), stride=(2, 2), padding=(2, 2))
)
```

1.8.3 Discriminator

```
In [0]: ## Discriminator
        class Discriminator(nn.Module):
          def __init__(self):
            super(Discriminator, self).__init__()

              #16, 16, 64
```

```
    self.conv1 = nn.Conv2d(4, 64, kernel_size=5, stride=2, padding = 2)
    self.bn1 = nn.BatchNorm2d(64)

      #8, 8 , 128
    self.conv2 = nn.Conv2d(64, 128, kernel_size=5, stride=2,padding = 2)
    self.bn2 = nn.BatchNorm2d(128)

      # 4, 4, 256
    self.conv3 = nn.Conv2d(128, 256, kernel_size=5, stride=2,padding = 2)

    self.bn3 = nn.BatchNorm2d(256)

      # 2, 2, 512

    self.conv4 = nn.Conv2d(256, 512, kernel_size=5, stride=2,padding = 2)
    self.bn4 = nn.BatchNorm2d(512)

      ## Linear
    self.fc1 = nn.Linear(276,2*2*512)

    self.fc2 = nn.Linear(4096,1)

  def forward(self,x,y):
    distribution = uniform.Uniform(torch.Tensor([-1]),torch.Tensor([1]))
    noise = distribution.sample(torch.Size([x.size(0),1, 32,32]))
    noise = noise.squeeze(4)

    h = torch.cat([x, noise.to(device)], dim=1)

    h = lrelu(self.bn1(self.conv1(h)))
    h = lrelu(self.bn2(self.conv2(h)))
    h = lrelu(self.bn3(self.conv3(h)))
    h = lrelu(self.bn4(self.conv4(h)))
    h = h.view(-1,2048)

    noise_z = distribution.sample(torch.Size([x.size(0),20])).squeeze().to(device)
    y = torch.cat([y,noise_z],dim=1)

    zh = lrelu(self.fc1(y))
    h = torch.cat([h, zh], dim=1)
    h = (self.fc2(h))


    return h, torch.sigmoid(h)



discriminator = Discriminator()
```

```
        discriminator.apply(init_weights)
        if is_cuda:
          discriminator = discriminator.to(device)


        print(discriminator)
```

```
Discriminator(
  (conv1): Conv2d(4, 64, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (conv2): Conv2d(64, 128, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
  (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (conv3): Conv2d(128, 256, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
  (bn3): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (conv4): Conv2d(256, 512, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2))
  (bn4): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (fc1): Linear(in_features=276, out_features=2048, bias=True)
  (fc2): Linear(in_features=4096, out_features=1, bias=True)
)
```

```
In [0]: ## conv conditional concat
        def conv_cond_concat(x, y):
            """Concatenate conditioning vector on feature map axis."""
            x_shapes = x.size()
            y_shapes = y.size()
            return torch.cat([
                x, y * torch.ones([x_shapes[0], x_shapes[1], x_shapes[2], y_shapes[3]])], 3)
```

```
In [0]: ## Z dimension -> X
        def generative_Y2X(z, reuse=None):
            h = encoder2(z)
            return h

        ## Encode - X -> latent representation Z
        def generative_X2Y(x, reuse=None):
            h = encoder1(x)
            return h
```

```
In [0]: def data_network(x, y, reuse=None):
            f, d = discriminator(x, y)
            return f.squeeze(1), d.squeeze(1)
```

```
In [0]: N =  Params.mb_size
        X = torch.randn(N, 3, 32, 32, device=device)
        z = torch.randn(N, Z_dim, device=device)
        z_gen = generative_X2Y(X)
        y_gen = generative_Y2X(z)
        fxz, Dxz = data_network(X, z_gen)
        fzx, Dzx = data_network(y_gen, z)
```

```
In [0]: ## Discriminator Loss

        D_loss = torch.mean(torch.log(Dzx) - torch.log(1- Dxz))

        ## Generator Loss
        L_x = -torch.mean((fxz))
        L_z = torch.mean(fzx)

        ## Total Generator Loss
        G_loss = L_x + L_z

        print(G_loss)
```

```
tensor(0.3048, device='cuda:0', grad_fn=<AddBackward0>)
```

```
In [0]: ## Reconstruction
        X_rec = generative_Y2X(z_gen)
        z_rec = generative_X2Y(y_gen)
```

```
In [0]: X_rec_loss = torch.mean(torch.abs(X-X_rec))
        Z_rec_loss = torch.mean(torch.abs(z-z_rec))
```

```
In [0]: print(X_rec_loss,Z_rec_loss)
```

```
tensor(1.1647, device='cuda:0', grad_fn=<MeanBackward1>) tensor(0.7903, device='cuda:0', grad_
```

```
In [0]: G_solver = optim.Adam(list(encoder1.parameters()) + list(encoder2.parameters()),
                              lr= Params.lr,betas =[0.5,0.5])
        D_solver = optim.Adam(discriminator.parameters(), lr= Params.lr,
                              betas =[0.5,0.5])
```

```
In [0]:
```

1.9 Training

```
In [0]: ## Training
        D_losses = []
        G_losses = []

        disc_steps = 1
        gen_steps = 1
        for epoch in range(100):
          dlosses = []
          glosses = []
          for idx, (data,labels) in enumerate(trainloader):

            ## generator loss, discriminator loss
```

```
_x = data
_x = _x/ 127.5 - 1
_x = _x.to(device)


z_sample = sample_Z(_x.size(0), Z_dim)
z_sample = torch.from_numpy(z_sample).to(device)

## Pass
for k in range(disc_steps):
  z_gen = generative_X2Y(_x)
  x_gen = generative_Y2X(z_sample)

  # discriminator
  fxz, Dxz = data_network(_x, z_gen)
  fzx, Dzx = data_network(x_gen, z_sample)


  D_solver.zero_grad()
  D_loss = -torch.mean(log(Dzx) + log(1-Dxz))
  D_loss.backward()
  D_solver.step()


## generator
for j in range(gen_steps):
  z_gen = generative_X2Y(_x)
  x_gen = generative_Y2X(z_sample)

  # discriminator
  fxz, Dxz = data_network(_x, z_gen)
  fzx, Dzx = data_network(x_gen, z_sample)

  L_x = -torch.mean(fxz)
  L_z = torch.mean(fzx)
  G_loss = L_x + L_z

  X_rec = generative_Y2X(z_gen)
  z_rec = generative_X2Y(x_gen)

  ## reconstruction.
  X_rec_loss = torch.mean(torch.abs(_x-X_rec))
  Z_rec_loss = torch.mean(torch.abs(z_sample-z_rec))

  G_loss = G_loss +  Params.lamb * X_rec_loss + Params.lamb * Z_rec_loss


  G_solver.zero_grad()
```

```
        G_loss.backward()



      ##
      if idx% 50 == 0:
        #torch.save(model.state_dict(), PATH)
        print("epoch: {}, iteration: {}, D_loss: {:.4}; G_loss: {:.4}"
              .format(epoch, idx,  D_loss.item(), G_loss.item()))

        ## test generated samples
        zz = sample_Z(Params.mb_size, Z_dim)
        zz_sample = torch.from_numpy(zz).to(device)

        ## generated z
        A =  generative_Y2X(zz_sample)

        imshow(torchvision.utils.make_grid(A.detach().cpu()))
        plt.show()


      G_solver.step()
      D_solver.step()

      dlosses.append(D_loss.item())
      glosses.append(G_loss.item())


    D_losses.append(np.mean(dlosses))
    G_losses.append(np.mean(glosses))
```

In [0]: