GAN_HW5_AmirPourmand

March 12, 2022

1 CE-40719: Deep Learning

1.1 HW5 - GAN (100 points)

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1.1.1 1) Import Libraries

[1]:
```
# !pip install colabcode > /dev/null
# from colabcode import ColabCode
# ColabCode(port=10000)
import sys
```

[2]:
```
import numpy as np
import torch
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
from torchvision import datasets, transforms

import matplotlib.pyplot as plt
%matplotlib inline
plt.rcParams['figure.figsize'] = (10, 3) # set default size of plots
```

1.1.2 2) Loading Dataset (10 points)

In this notebook, you will use `MNIST` dataset to train your GAN. You can see more information about this dataset here. This dataset is a 10 class dataset. It contains 60000 grayscale images (50000 for train and 10000 for test or validation) each with shape (3, 28, 28). Every image has a corresponding label which is a number in range 0 to 9.

[3]:

```
# MNIST Dataset
train_dataset = datasets.MNIST(root='./mnist/', train=True,␣
 ↪transform=transforms.ToTensor(), download=True)
test_dataset = datasets.MNIST(root='./mnist/', train=False,␣
 ↪transform=transforms.ToTensor(), download=True)
```

```
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz to
./mnist/MNIST/raw/train-images-idx3-ubyte.gz

  0%|          | 0/9912422 [00:00<?, ?it/s]

Extracting ./mnist/MNIST/raw/train-images-idx3-ubyte.gz to ./mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz to
./mnist/MNIST/raw/train-labels-idx1-ubyte.gz

  0%|          | 0/28881 [00:00<?, ?it/s]

Extracting ./mnist/MNIST/raw/train-labels-idx1-ubyte.gz to ./mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz to
./mnist/MNIST/raw/t10k-images-idx3-ubyte.gz

  0%|          | 0/1648877 [00:00<?, ?it/s]

Extracting ./mnist/MNIST/raw/t10k-images-idx3-ubyte.gz to ./mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz to
./mnist/MNIST/raw/t10k-labels-idx1-ubyte.gz

  0%|          | 0/4542 [00:00<?, ?it/s]

Extracting ./mnist/MNIST/raw/t10k-labels-idx1-ubyte.gz to ./mnist/MNIST/raw
```

[4]:
```
# Device configuration
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')

################ Problem 01 (5 pts) ################
# define hyper parameters
batch_size = 64
d_lr = 1e-4
g_lr = 1e-4
n_epochs = 100
####################### End ########################
z_dim = 100
```

[5]:
```
################ Problem 02 (5 pts) ################
# Define Dataloaders
changed_dataset = torch.utils.data.TensorDataset(train_dataset.data.float()/
 ↪255, train_dataset.targets)
changed_dataset = torch.utils.data.TensorDataset(test_dataset.data.float()/255,␣
 ↪test_dataset.targets)

train_loader = torch.utils.data.DataLoader(dataset=changed_dataset,␣
 ↪batch_size=batch_size, shuffle=True)
test_loader = torch.utils.data.DataLoader(dataset=changed_dataset,␣
 ↪batch_size=batch_size, shuffle=False)
####################### End ########################
```

1.1.3 3) Defining Network (30 points)

At this stage, you should define a network that improves your GAN training and prevents problems such as mode collapse and vanishing gradients.

[6]:
```
class Discriminator(nn.Module):
    def __init__(self):
        super().__init__()

        self.discriminator = nn.Sequential(
            ################ Problem 03 (15 pts) ################
            # use linear or convolutional layer
            # use arbitrary techniques to stabilize training
            nn.Dropout(),
            nn.Linear(784, 256),
            nn.LeakyReLU(0.1),
            nn.Dropout(),
            nn.Linear(256, 128),
            nn.LeakyReLU(0.1),
            nn.Linear(128, 64),
            nn.Dropout(),
            nn.LeakyReLU(0.1),
            nn.Linear(64, 1),
            nn.Sigmoid()
            ####################### End ########################
        )

    def forward(self, x):
        return self.discriminator(x)


class Generator(nn.Module):
    def __init__(self):
        super().__init__()

        self.generator = nn.Sequential(
            ################ Problem 04 (15 pts) ################
            # use linear or convolutional layer
            # use arbitrary techniques to stabilize training
            nn.Linear(128, 128),
            nn.LeakyReLU(0.1),
            nn.Linear(128, 256),
            nn.LeakyReLU(0.1),
            nn.Linear(256, 512),
            nn.LeakyReLU(0.1),
            nn.Linear(512, 784),
            nn.Sigmoid()
            ####################### End ########################
        )

    def forward(self, z):
        return self.generator(z)
```

1.1.4 4) Train the Network

At this step, you are going to train your network.

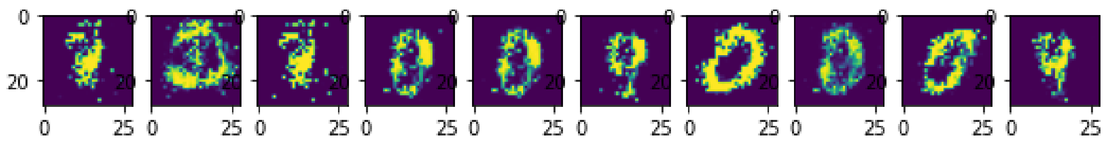
[7]:
```
################ Problem 05 (5 pts) ################
# Create instances of modules (discriminator and generator)
# don't forget to put your models on device
discriminator = Discriminator().to(device)
generator = Generator().to(device)
####################### End ########################
```

[8]:
```
################ Problem 06 (5 pts) ################
# Define two optimizer for discriminator and generator
d_optimizer = optim.Adam(discriminator.parameters(),lr=d_lr)
g_optimizer = optim.Adam(generator.parameters(),lr=g_lr)
####################### End ########################
```

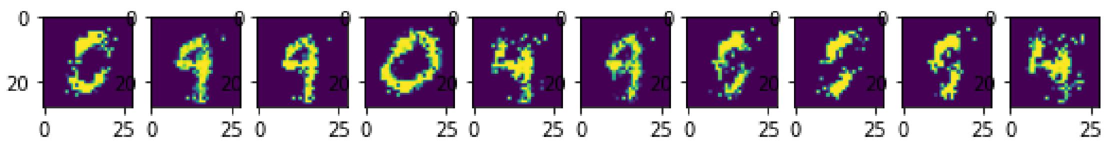
[15]:
```
plot_frequency = 8

for epoch in range(n_epochs):
    for i, (images, labels) in enumerate(train_loader):

        ################ Problem 07 (15 pts) ################
        # put your inputs on device
        # Prepare what you need for training, like inputs for modules and␣
 ↪variables for computing loss
```

```
        images = images.flatten(start_dim=1)

        real_img = images.to(device)

        fake_labels = torch.zeros(images.shape[0], 1).to(device)
        real_labels = torch.ones(images.shape[0], 1).to(device)
        z = torch.randn(images.shape[0], 128).to(device)

        generated_images = generator(z)

        d_optimizer.zero_grad()

        ####################### End ########################



        ################ Problem 08 (10 pts) ################
        # calculate discriminator loss and update it

        z = torch.randn(images.shape[0], 128).to(device)
        generated_images = generator(z)

        g_optimizer.zero_grad()

        d_loss = (F.binary_cross_entropy(discriminator(generated_images.
↪detach()), fake_labels) +
                  F.binary_cross_entropy(discriminator(real_img), real_labels))
        d_loss.backward()
        d_optimizer.step()

        ####################### End ########################



        ################ Problem 09 (10 pts) ################
        # calculate generator loss and update it


        g_loss = F.binary_cross_entropy(discriminator(generated_images),␣
↪real_labels)
        g_loss.backward()
        g_optimizer.step()


        ####################### End ########################
```

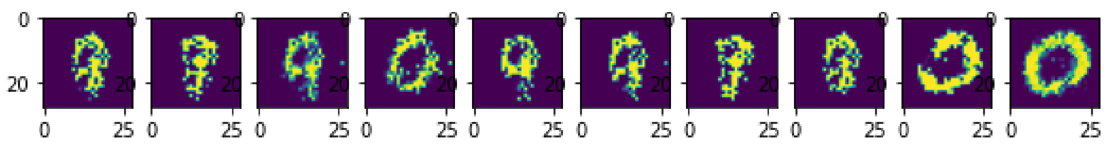
```
    ################ Problem 10 (10 pts) ################
    # plot some of the generated pictures based on plot frequency variable

    if (epoch % plot_frequency == 0):
        plt.subplots(1,10)
        for j in range(10):
            plt.subplot(1,10,j+1)
            plt.imshow(generated_images[j].detach().cpu().view(28, 28).numpy())
        plt.show()

    ######################## End ########################

    print("epoch: {} \t discriminator last batch loss: {} \t generator last␣
↪batch loss: {}".format(epoch + 1,
                                                                                ␣
↪              d_loss.item(),
                                                                                ␣
↪              g_loss.item())
    )
```



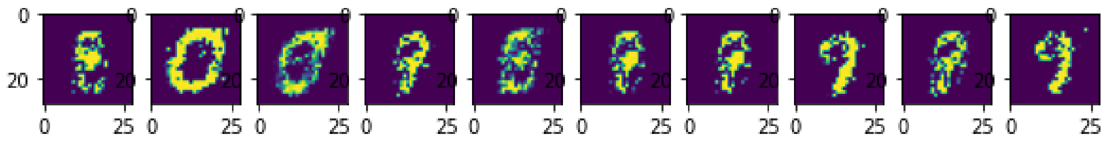
```
epoch: 1         discriminator last batch loss: 0.4526025056838989
generator last batch loss: 5.285737991333008
epoch: 2         discriminator last batch loss: 0.43249544501304626
generator last batch loss: 4.652981758117676
epoch: 3         discriminator last batch loss: 0.18930116295814514
generator last batch loss: 4.307076930999756
epoch: 4         discriminator last batch loss: 0.15187987685203552
generator last batch loss: 3.678199291229248
epoch: 5         discriminator last batch loss: 0.17373239994049072
generator last batch loss: 4.404343605041504
epoch: 6         discriminator last batch loss: 0.32422640919685364
generator last batch loss: 4.331548690795898
epoch: 7         discriminator last batch loss: 0.25898197293281555
generator last batch loss: 4.303992748260498
epoch: 8         discriminator last batch loss: 0.32791081070899963
generator last batch loss: 4.407011032104492
```



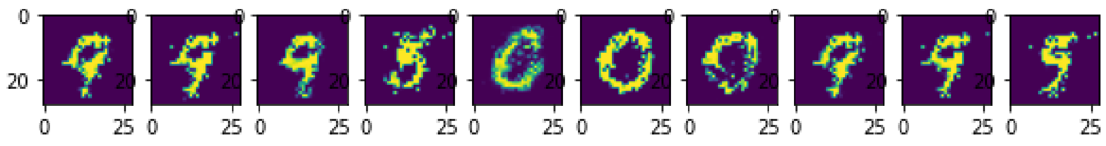
```
epoch: 9        discriminator last batch loss: 0.11968954652547836
generator last batch loss: 4.092791557312012
epoch: 10       discriminator last batch loss: 0.3881288170814514
generator last batch loss: 4.699208736419678
epoch: 11       discriminator last batch loss: 0.14748160541057587
generator last batch loss: 4.96040678024292
epoch: 12       discriminator last batch loss: 0.16801181435585022
generator last batch loss: 5.55793571472168
epoch: 13       discriminator last batch loss: 0.2709391713142395
generator last batch loss: 4.721650123596191
epoch: 14       discriminator last batch loss: 0.0771351307630539
generator last batch loss: 4.4544453620910645
epoch: 15       discriminator last batch loss: 0.05643106997013092
generator last batch loss: 4.256270885467529
epoch: 16       discriminator last batch loss: 0.11224986612796783
generator last batch loss: 5.817045211791992
```



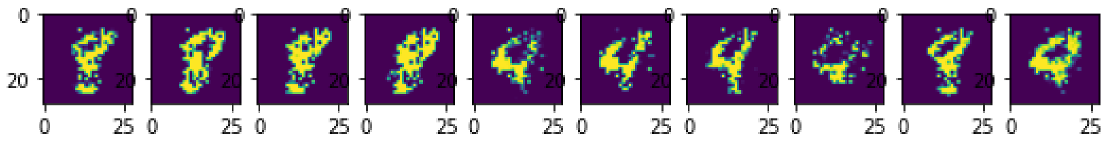
```
epoch: 17       discriminator last batch loss: 0.07536284625530243
generator last batch loss: 4.191890716552734
epoch: 18       discriminator last batch loss: 0.07661587744951248
generator last batch loss: 4.785077095031738
epoch: 19       discriminator last batch loss: 0.3628731369972229
generator last batch loss: 5.472227096557617
epoch: 20       discriminator last batch loss: 0.1707061380147934
generator last batch loss: 4.6116461753845215
epoch: 21       discriminator last batch loss: 0.039693281054496765
generator last batch loss: 4.726522445678711
epoch: 22       discriminator last batch loss: 0.408406138420105
generator last batch loss: 4.732564449310303
epoch: 23       discriminator last batch loss: 0.22687120735645294
generator last batch loss: 4.7030439376831055
epoch: 24       discriminator last batch loss: 0.19694030284881592
generator last batch loss: 4.343166828155518
```



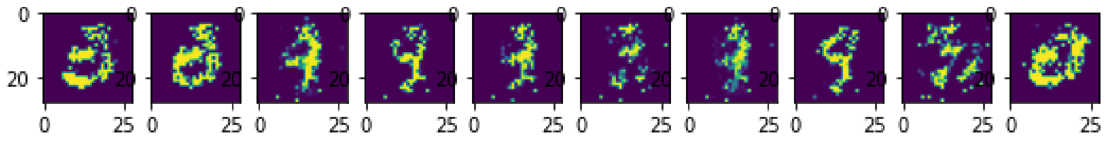
```
epoch: 25        discriminator last batch loss: 0.30752331018447876
generator last batch loss: 4.702264785766602
epoch: 26        discriminator last batch loss: 0.15181729197502136
generator last batch loss: 6.414487361907959
epoch: 27        discriminator last batch loss: 0.04409197345376015
generator last batch loss: 5.295083045959473
epoch: 28        discriminator last batch loss: 0.08326520770788193
generator last batch loss: 6.03814172744751
epoch: 29        discriminator last batch loss: 0.05310313403606415
generator last batch loss: 6.229020595550537
epoch: 30        discriminator last batch loss: 0.15731941163539886
generator last batch loss: 5.697305202484131
epoch: 31        discriminator last batch loss: 0.4631544053554535
generator last batch loss: 5.523553371429443
epoch: 32        discriminator last batch loss: 0.2697069048881531
generator last batch loss: 5.838858604431152
```



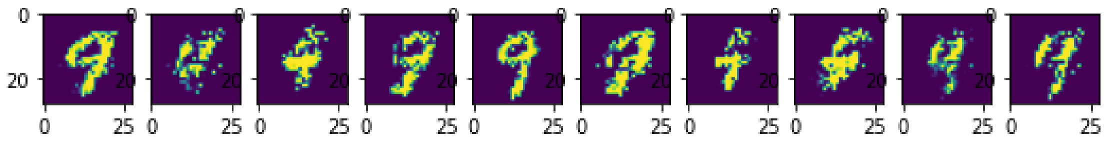
```
epoch: 33        discriminator last batch loss: 0.3550873100757599
generator last batch loss: 5.327003002166748
epoch: 34        discriminator last batch loss: 0.05874096602201462
generator last batch loss: 5.075199127197266
epoch: 35        discriminator last batch loss: 0.16970370709896088
generator last batch loss: 4.122466564178467
epoch: 36        discriminator last batch loss: 0.1823093444108963
generator last batch loss: 3.6456737518310547
epoch: 37        discriminator last batch loss: 0.3489549160003662
generator last batch loss: 4.5043535232543945
epoch: 38        discriminator last batch loss: 0.26233819127082825
generator last batch loss: 4.710198879241943
epoch: 39        discriminator last batch loss: 0.07435431331396103
generator last batch loss: 5.282116889953613
epoch: 40        discriminator last batch loss: 0.12258202582597733
generator last batch loss: 5.011265277862549
```



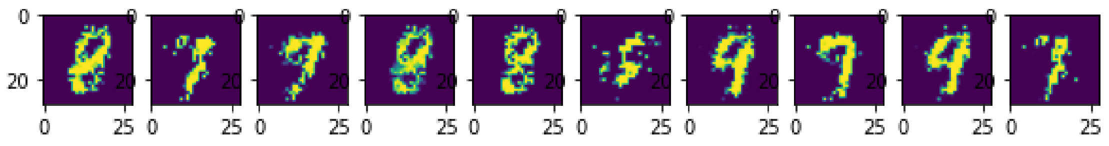
```
epoch: 41        discriminator last batch loss: 0.020369620993733406
generator last batch loss: 5.6662774085998535
epoch: 42        discriminator last batch loss: 0.17193041741847992
generator last batch loss: 5.614759922027588
epoch: 43        discriminator last batch loss: 0.3258708417415619
generator last batch loss: 4.997150421142578
epoch: 44        discriminator last batch loss: 0.4404647946357727
generator last batch loss: 4.949891090393066
epoch: 45        discriminator last batch loss: 0.07338154315948486
generator last batch loss: 7.295401096343994
epoch: 46        discriminator last batch loss: 0.059725455939769745
generator last batch loss: 6.274524688720703
epoch: 47        discriminator last batch loss: 0.07014722377061844
generator last batch loss: 6.476493835449219
epoch: 48        discriminator last batch loss: 0.06962615996599197
generator last batch loss: 4.7340803146362305
```



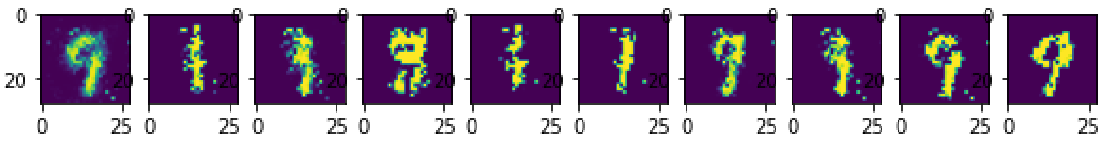
```
epoch: 49        discriminator last batch loss: 0.2701271176338196
generator last batch loss: 4.875622272491455
epoch: 50        discriminator last batch loss: 0.14645716547966003
generator last batch loss: 4.428819179534912
epoch: 51        discriminator last batch loss: 0.3282139301300049
generator last batch loss: 4.455596923828125
epoch: 52        discriminator last batch loss: 0.08166883885860443
generator last batch loss: 3.972010612487793
epoch: 53        discriminator last batch loss: 0.17902792990207672
generator last batch loss: 4.952468395233154
epoch: 54        discriminator last batch loss: 0.7330385446548462
generator last batch loss: 4.905087471008301
epoch: 55        discriminator last batch loss: 0.24163632094860077
generator last batch loss: 4.64194393157959
epoch: 56        discriminator last batch loss: 0.07552099227905273
generator last batch loss: 5.131409645080566
```



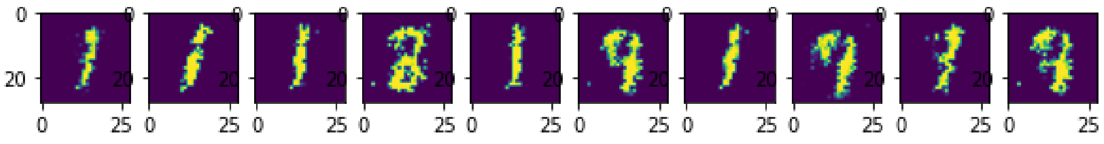
```
epoch: 57        discriminator last batch loss: 0.09516200423240662
generator last batch loss: 4.626585006713867
epoch: 58        discriminator last batch loss: 0.1417853832244873
generator last batch loss: 4.652469635009766
epoch: 59        discriminator last batch loss: 0.2954828441143036
generator last batch loss: 4.598642349243164
epoch: 60        discriminator last batch loss: 0.07053083181381226
generator last batch loss: 5.158090591430664
epoch: 61        discriminator last batch loss: 0.365439772605896
generator last batch loss: 4.7098822593688965
epoch: 62        discriminator last batch loss: 0.047677841037511826
generator last batch loss: 3.6762924194335938
epoch: 63        discriminator last batch loss: 0.19115468859672546
generator last batch loss: 3.902686595916748
epoch: 64        discriminator last batch loss: 0.3000842034816742
generator last batch loss: 3.9719202518463135
```



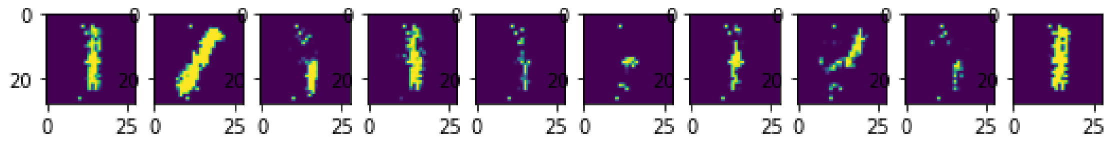
```
epoch: 65        discriminator last batch loss: 0.15772566199302673
generator last batch loss: 3.6041245460510254
epoch: 66        discriminator last batch loss: 0.36840155720710754
generator last batch loss: 3.1781678199768066
epoch: 67        discriminator last batch loss: 0.22352418303489685
generator last batch loss: 3.386303186416626
epoch: 68        discriminator last batch loss: 0.28189268708229065
generator last batch loss: 4.055626392364502
epoch: 69        discriminator last batch loss: 0.25824469327926636
generator last batch loss: 3.870128631591797
epoch: 70        discriminator last batch loss: 0.18352827429771423
generator last batch loss: 3.2309844493865967
epoch: 71        discriminator last batch loss: 0.3790420591831207
generator last batch loss: 2.6286163330078125
epoch: 72        discriminator last batch loss: 0.4964669346809387
generator last batch loss: 3.882441997528076
```



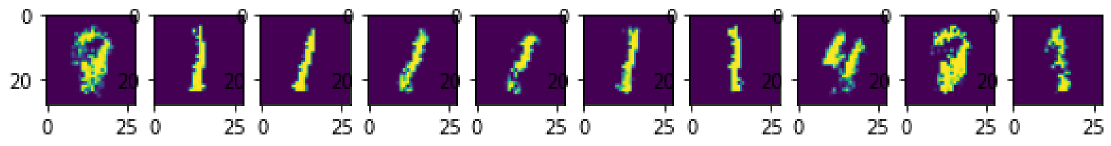
```
epoch: 73        discriminator last batch loss: 0.13859772682189941
generator last batch loss: 4.086652755737305
epoch: 74        discriminator last batch loss: 0.0986773818731308
generator last batch loss: 3.3983774185180664
epoch: 75        discriminator last batch loss: 0.33908355236053467
generator last batch loss: 2.818023681640625
epoch: 76        discriminator last batch loss: 0.37425583600997925
generator last batch loss: 3.000114917755127
epoch: 77        discriminator last batch loss: 0.36668747663497925
generator last batch loss: 3.1483631134033203
epoch: 78        discriminator last batch loss: 0.15351355075836182
generator last batch loss: 3.4849298000335693
epoch: 79        discriminator last batch loss: 0.16643989086151123
generator last batch loss: 3.6033639907836914
epoch: 80        discriminator last batch loss: 0.4028579294681549
generator last batch loss: 3.202993392944336
```



```
epoch: 81        discriminator last batch loss: 0.34524911642074585
generator last batch loss: 2.919123649597168
epoch: 82        discriminator last batch loss: 0.35261666774749756
generator last batch loss: 3.1046531200408936
epoch: 83        discriminator last batch loss: 0.10104389488697052
generator last batch loss: 3.797217845916748
epoch: 84        discriminator last batch loss: 0.2141474187374115
generator last batch loss: 3.434494733810425
epoch: 85        discriminator last batch loss: 0.8162918090820312
generator last batch loss: 2.8962299823760986
epoch: 86        discriminator last batch loss: 0.36329665780067444
generator last batch loss: 2.8522610664367676
epoch: 87        discriminator last batch loss: 0.5243480205535889
generator last batch loss: 3.0861964225769043
epoch: 88        discriminator last batch loss: 0.31290438771247864
generator last batch loss: 3.705423355102539
```



```
epoch: 89        discriminator last batch loss: 0.31781554222106934
generator last batch loss: 2.8093068599700928
epoch: 90        discriminator last batch loss: 0.47039374709129333
generator last batch loss: 2.781459093093872
epoch: 91        discriminator last batch loss: 0.31486403942108154
generator last batch loss: 3.0602493286132812
epoch: 92        discriminator last batch loss: 0.4269317388534546
generator last batch loss: 3.008514881134033
epoch: 93        discriminator last batch loss: 0.26753953099250793
generator last batch loss: 2.7242507934570312
epoch: 94        discriminator last batch loss: 0.34563255310058594
generator last batch loss: 2.4893853664398193
epoch: 95        discriminator last batch loss: 0.4548366665840149
generator last batch loss: 2.9345273971557617
epoch: 96        discriminator last batch loss: 0.47257599234580994
generator last batch loss: 3.058396577835083
```



```
epoch: 97        discriminator last batch loss: 0.12716469168663025
generator last batch loss: 2.4509408473968506
epoch: 98        discriminator last batch loss: 0.32557404041290283
generator last batch loss: 3.260545253753662
epoch: 99        discriminator last batch loss: 0.30183959007263184
generator last batch loss: 3.4616000652313232
epoch: 100       discriminator last batch loss: 0.4865638017654419
generator last batch loss: 2.9558064937591553
```

1.1.5 5) Save Generator

Save your final generator parameters. Upload it with your other files.

[18]:
```
################ Problem 11 (5 pts) ################
# save state dict of your generator
```

```
path = "/content/my_parameters"
torch.save(generator.state_dict(), path)
####################### End ########################
```

[ ]:

```
```