```python
from google.colab import drive
drive.mount('/content/drive')

! cp '/content/drive/MyDrive/24788-24789/code_q1_template/airfoils.zip' .
! unzip airfoils.zip
```

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```

```
Mounted at /content/drive
Archive:  airfoils.zip
   creating: airfoils/
  inflating: airfoils/2032c_clean.dat
  inflating: airfoils/a18sm_clean.dat
  inflating: airfoils/a18_clean.dat
  inflating: airfoils/a63a108c_clean.dat
  inflating: airfoils/ag03_clean.dat
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inflating: airfoils/sd7003_clean.dat
inflating: airfoils/sd7032_clean.dat
inflating: airfoils/sd7034_clean.dat
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inflating: airfoils/sd7062_clean.dat
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inflating: airfoils/sd7084_clean.dat
inflating: airfoils/sd7090_clean.dat
inflating: airfoils/sd8000_clean.dat
inflating: airfoils/sd8020_clean.dat
inflating: airfoils/sd8040_clean.dat
inflating: airfoils/sg6040_clean.dat
inflating: airfoils/sg6041_clean.dat
inflating: airfoils/sg6042_clean.dat
inflating: airfoils/sg6043_clean.dat
inflating: airfoils/sg6050_clean.dat
inflating: airfoils/sg6051_clean.dat
inflating: airfoils/sm701_clean.dat
inflating: airfoils/sokolov_clean.dat
inflating: airfoils/spicasm_clean.dat
inflating: airfoils/ssca07_clean.dat
inflating: airfoils/ssca09_clean.dat
inflating: airfoils/stcyr171_clean.dat
inflating: airfoils/stcyr172_clean.dat
inflating: airfoils/stcyr234_clean.dat
inflating: airfoils/stcyr24_clean.dat
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inflating: airfoils/strand_clean.dat
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inflating: airfoils/tempest2_clean.dat
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inflating: airfoils/ui1720_clean.dat
inflating: airfoils/ultimate_clean.dat
inflating: airfoils/us1000root_clean.dat
inflating: airfoils/usa22_clean.dat
inflating: airfoils/usa25_clean.dat
inflating: airfoils/usa26_clean.dat
inflating: airfoils/usa27m2_clean.dat
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inflating: airfoils/usa45m_clean.dat
inflating: airfoils/usa45_clean.dat
inflating: airfoils/usa46_clean.dat
inflating: airfoils/usa48_clean.dat
inflating: airfoils/usa49_clean.dat
```

```
inflating: airfoils/usa50_clean.dat
inflating: airfoils/usa51_clean.dat
inflating: airfoils/usa5_clean.dat
inflating: airfoils/usa98_clean.dat
inflating: airfoils/usnps4_clean.dat
inflating: airfoils/v13006_clean.dat
inflating: airfoils/v13009_clean.dat
inflating: airfoils/v23010_clean.dat
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inflating: airfoils/vr11x_clean.dat
inflating: airfoils/vr12_clean.dat
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inflating: airfoils/vr8_clean.dat
inflating: airfoils/vr9_clean.dat
inflating: airfoils/waspsm_clean.dat
inflating: airfoils/wb13535sm_clean.dat
inflating: airfoils/wb140_clean.dat
inflating: airfoils/whitcomb_clean.dat
inflating: airfoils/xfoil.exe
inflating: airfoils/ys900_clean.dat
inflating: airfoils/ys915_clean.dat
inflating: airfoils/ys930_clean.dat
```

In [2]:
```python
# dataset.py

import os
import torch
import numpy as np
from torch.utils.data import Dataset


class AirfoilDataset(Dataset):
    '''
    airfoil dataset: no need to modify
    '''
    def __init__(self, path='./airfoils'):
        super(AirfoilDataset, self).__init__()
        self._X = []    # x coordinates of all airfoils (shared)
        self._Y = []    # y coordinates of all airfoils
        self.names = [] # name of all airfoils
        self.norm_coeff = 0     # normalization coeff to scale y to [-1, 1]
        airfoil_fn = [afn for afn in os.listdir(path) if afn.endswith('.dat')]

        # get x coordinates of all airfoils
        with open(os.path.join(path, airfoil_fn[0]), 'r', encoding="utf8", errors='ignore') as f:
            raw_data = f.readlines()
            for idx in range(len(raw_data)):
                raw_xy = raw_data[idx].split(' ')
                while "" in raw_xy:
                    raw_xy.remove("")
                self._X.append(float(raw_xy[0]))
        self._X = np.array(self._X)

        # get y coordinates of each airfoils
        for idx, fn in enumerate(airfoil_fn):
            with open(os.path.join(path, fn), 'r', encoding="utf8", errors='ignore') as f:
                self.names.append(fn[:-10])
                raw_data = f.readlines()
                airfoil = np.empty(self._X.shape[0])
                for i in range(len(raw_data)):
                    raw_xy = raw_data[i].split(' ')
                    while "" in raw_xy:
                        raw_xy.remove("")
                    curr_y = float(raw_xy[1])
                    airfoil[i] = curr_y
                    self.norm_coeff = max(self.norm_coeff, np.abs(curr_y))
                self._Y.append(airfoil)

        self._Y = np.array([airfoil / self.norm_coeff for airfoil in self._Y], dtype=np.float32)

    def get_x(self):
        '''
        get shared x coordinates
        '''
        return self._X

    def get_y(self):
        '''
        get y coordinates of all airfoils
        '''
        return self._Y

    def __getitem__(self, idx):
        return self._Y[idx], self.names[idx]

    def __len__(self):
        return len(self._Y)
```

```python
In [3]:  # utils.py

'''
Utility functions
Free from to add functions if needed
'''

import torch
import matplotlib.pyplot as plt


def plot_airfoils(airfoil_x, airfoil_y):
    '''
    plot airfoils: no need to modify
    '''
    idx = 0
    fig, ax = plt.subplots(nrows=4, ncols=4)
    for row in ax:
        for col in row:
            col.scatter(airfoil_x, airfoil_y[idx, :], s=0.6, c='black')
            col.axis('off')
            col.axis('equal')
            idx += 1
    plt.show()
```

```python
In [4]:  # gan.py

import torch
import torch.nn as nn


class Discriminator(nn.Module):
    def __init__(self, input_dim):
        super(Discriminator, self).__init__()
        # build your model here
        # your output should be of dim (batch_size, 1)
        # since discriminator is a binary classifier
        self.model = nn.Sequential(
            nn.Linear(int(np.prod(input_dim)), 512),
            nn.LeakyReLU(0.1, inplace=True),
            nn.Linear(512, 256),
            nn.LeakyReLU(0.1, inplace=True),
            nn.Linear(256, 128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.Linear(128, 1),
            nn.Sigmoid(),
        )

    def forward(self, x):
        # define your feedforward pass
        flat_input = x.view(x.size(0), -1)
        return self.model(flat_input)


class Generator(nn.Module):
    def __init__(self, latent_dim, airfoil_dim):
        super(Generator, self).__init__()
        # build your model here
        # your output should be of dim (batch_size, airfoil_dim)
        # you can use tanh() as the activation for the last layer
        # since y coord of airfoils range from -1 to 1
        self.airfoil_dim = int(airfoil_dim)

        def block(in_feat, out_feat, normalize=True):
            layers = [nn.Linear(in_feat, out_feat)]
            if normalize:
                layers.append(nn.BatchNorm1d(out_feat, 0.8))
            layers.append(nn.LeakyReLU(0.1, inplace=True))
            return layers

        self.model = nn.Sequential(
            *block(latent_dim, 64, normalize=False),
            *block(64, 256),
            *block(256, 512),
            *block(512, 1024),
            nn.Linear(1024, int(np.prod(airfoil_dim))),
            nn.Tanh()
        )

    def forward(self, x):
        # define your feedforward pass

        out = self.model(x)
        airfoil = out.view(out.size(0), self.airfoil_dim)
        return airfoil
```

```python
# train_gan.py

'''
train and test GAN model on airfoils
'''

import torch
import torch.nn as nn
from torch.autograd import Variable
from torch.utils.data import DataLoader
from torch.optim import Adam
import numpy as np

# from dataset import AirfoilDataset
# from gan import Discriminator, Generator
# from utils import *


def main():
    # check if cuda available
    device = 'cuda:0' if torch.cuda.is_available() else 'cpu'

    # define dataset and dataloader
    dataset = AirfoilDataset()
    airfoil_x = dataset.get_x()
    airfoil_dim = airfoil_x.shape[0]
    airfoil_dataloader = DataLoader(dataset, batch_size=16, shuffle=True)

    # hyperparameters
    latent_dim = 16 # please do not change latent dimension
    lr_dis = 0.0001 # discriminator learning rate
    lr_gen = 0.0001 # generator learning rate
    num_epochs = 60

    # build the model
    dis = Discriminator(input_dim=airfoil_dim).to(device)
    gen = Generator(latent_dim=latent_dim, airfoil_dim=airfoil_dim).to(device)
    print("Discriminator model:\n", dis)
    print("Generator model:\n", gen)

    # define your GAN loss function here
    # you may need to define your own GAN loss function/class
    # loss = ?
    loss = torch.nn.BCELoss()
    # define optimizer for discriminator and generator separately
    optim_dis = Adam(dis.parameters(), lr=lr_dis)
    optim_gen = Adam(gen.parameters(), lr=lr_gen)

    dis_loss_list = []
    gen_loss_list = []

    # train the GAN model
    for epoch in range(num_epochs):
        for n_batch, (local_batch, __) in enumerate(airfoil_dataloader):
            y_real = local_batch.to(device)

            valid = Variable(torch.Tensor(local_batch.size(0), 1).fill_(1.0), requires_grad=False)
            fake = Variable(torch.Tensor(local_batch.size(0), 1).fill_(0.0), requires_grad=False)

            # Noise for generator input
            z = Variable(torch.Tensor(np.random.normal(0, 1, (local_batch.shape[0], latent_dim))))

            y_fake = gen(z)
            # train discriminator

            # calculate customized GAN loss for discriminator
            # enc_loss = loss(...)

            optim_dis.zero_grad()

            real_loss = loss(dis(y_real), valid)
            fake_loss = loss(dis(y_fake.detach()), fake)
            loss_dis = (real_loss + fake_loss)/2
            loss_dis.backward()
            optim_dis.step()

            dis_loss_list.append(loss_dis.item())

            # train generator

            # calculate customized GAN loss for generator
            # enc_loss = loss(...)

            optim_gen.zero_grad()

            loss_gen = loss(dis(y_fake), valid)
            loss_gen.backward()
            optim_gen.step()

            gen_loss_list.append(loss_gen.item())

            # print loss while training
            if (n_batch + 1) % 30 == 0:
                print("Epoch: [{}/{}], Batch: {}, Discriminator loss: {}, Generator loss: {}".format(
                    epoch, num_epochs, n_batch, loss_dis.item(), loss_gen.item()))

    # test trained GAN model
```

```python
    # test trained GAN model
    num_samples = 100
    # create random noise
    noise = torch.randn((num_samples, latent_dim)).to(device)
    # generate airfoils
    gen_airfoils = gen(noise)
    if 'cuda' in device:
        gen_airfoils = gen_airfoils.detach().cpu().numpy()
    else:
        gen_airfoils = gen_airfoils.detach().numpy()

    # plot generated airfoils
    plot_airfoils(airfoil_x, gen_airfoils)


    plt.plot(gen_loss_list, label="gen_loss")
    plt.plot(dis_loss_list, label="dis_loss")
    plt.legend()
    plt.title("Generator and Discriminator Loss vs Epochs")
    plt.xlabel("Epoch")
    plt.ylabel("Loss")
    plt.show()

    save_path = './drive/MyDrive/24788-24789/code_q1_template/p1_gan_dis_model.pth'
    torch.save(dis.state_dict(), save_path)
    save_path = './drive/MyDrive/24788-24789/code_q1_template/p1_gan_gen_model.pth'
    torch.save(gen.state_dict(), save_path)
if __name__ == "__main__":
    main()
```

```
Discriminator model:
 Discriminator(
  (model): Sequential(
    (0): Linear(in_features=200, out_features=512, bias=True)
    (1): LeakyReLU(negative_slope=0.1, inplace=True)
    (2): Linear(in_features=512, out_features=256, bias=True)
    (3): LeakyReLU(negative_slope=0.1, inplace=True)
    (4): Linear(in_features=256, out_features=128, bias=True)
    (5): LeakyReLU(negative_slope=0.1, inplace=True)
    (6): Linear(in_features=128, out_features=1, bias=True)
    (7): Sigmoid()
  )
)
Generator model:
 Generator(
  (model): Sequential(
    (0): Linear(in_features=16, out_features=64, bias=True)
    (1): LeakyReLU(negative_slope=0.1, inplace=True)
    (2): Linear(in_features=64, out_features=256, bias=True)
    (3): BatchNorm1d(256, eps=0.8, momentum=0.1, affine=True, track_running_stats=True)
    (4): LeakyReLU(negative_slope=0.1, inplace=True)
    (5): Linear(in_features=256, out_features=512, bias=True)
    (6): BatchNorm1d(512, eps=0.8, momentum=0.1, affine=True, track_running_stats=True)
    (7): LeakyReLU(negative_slope=0.1, inplace=True)
    (8): Linear(in_features=512, out_features=1024, bias=True)
    (9): BatchNorm1d(1024, eps=0.8, momentum=0.1, affine=True, track_running_stats=True)
    (10): LeakyReLU(negative_slope=0.1, inplace=True)
    (11): Linear(in_features=1024, out_features=200, bias=True)
    (12): Tanh()
  )
)
Epoch: [0/60], Batch: 29, Discriminator loss: 0.6488394141197205, Generator loss: 0.6716203093528748
Epoch: [0/60], Batch: 59, Discriminator loss: 0.6774021983146667, Generator loss: 0.6706845164299011
Epoch: [0/60], Batch: 89, Discriminator loss: 0.7139972448348999, Generator loss: 0.9795606136322021
Epoch: [1/60], Batch: 29, Discriminator loss: 0.6673747301101685, Generator loss: 0.841623067855835
Epoch: [1/60], Batch: 59, Discriminator loss: 0.5652740597724915, Generator loss: 0.8356156349182129
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Epoch: [2/60], Batch: 59, Discriminator loss: 0.5644704699516296, Generator loss: 1.2172216176986694
Epoch: [2/60], Batch: 89, Discriminator loss: 0.38568922877311707, Generator loss: 1.6215860843658447
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Epoch: [11/60], Batch: 89, Discriminator loss: 0.5257021188735962, Generator loss: 0.867274820804596
Epoch: [12/60], Batch: 29, Discriminator loss: 0.7029886841773987, Generator loss: 0.8788097500801086
```

```
Epoch: [12/60], Batch: 59, Discriminator loss: 0.7542548179626465, Generator loss: 0.7773436903953552
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```

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```
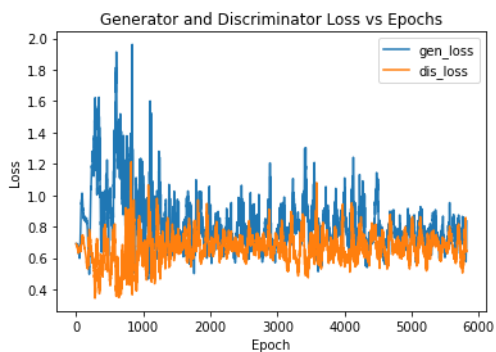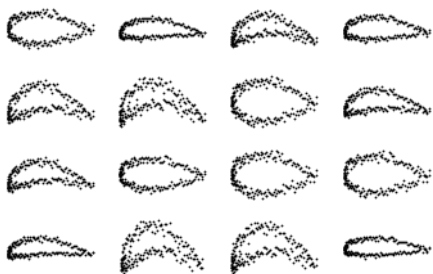
```python
# vae.py

import torch
import torch.nn as nn


class Encoder(nn.Module):
    def __init__(self, input_dim, latent_dim):
        super(Encoder, self).__init__()
        # build your model here
        # your model should output a predicted mean and a predicted std of the encoding
        # both should be of dim (batch_size, latent_dim)
        self.model = nn.Sequential(
            nn.Linear(input_dim, 128),
            nn.ReLU(),
            nn.Linear(128, 64),
            nn.ReLU(),
            nn.Linear(64, 32),
            nn.ReLU(),
        )
        self.mean = nn.Linear(32, latent_dim)
        self.std = nn.Linear(32, latent_dim)

    def forward(self, x):
        # define your feedforward pass
        enc = self.model(x)

        return self.mean(enc), self.std(enc).exp()


class Decoder(nn.Module):
    def __init__(self, latent_dim, output_dim):
        super(Decoder, self).__init__()
        # build your model here
        # your output should be of dim (batch_size, output_dim)
        # you can use tanh() as the activation for the last layer
        # since y coord of airfoils range from -1 to 1
        self.model = nn.Sequential(
            nn.Linear(latent_dim, 32),
            nn.ReLU(),
            nn.Linear(32, 64),
            nn.ReLU(),
            nn.Linear(64, 128),
            nn.ReLU(),
            nn.Linear(128, output_dim),
            nn.Tanh()
        )
    def forward(self, x):
        # define your feedforward pass
        return self.model(x)


class VAE(nn.Module):
    def __init__(self, airfoil_dim, latent_dim):
        super(VAE, self).__init__()
        self.enc = Encoder(airfoil_dim, latent_dim)
        self.dec = Decoder(latent_dim, airfoil_dim)

    def reparameterize(self, mu, std):
        # std = torch.exp(0.5*logvar)
        eps = torch.randn_like(std)
        return mu + std*eps

    def forward(self, x):
        # define your feedforward pass
        mu, std = self.enc(x.view(-1, 200))
        z = self.reparameterize(mu, std)

        return self.dec(z), mu, std

    def decode(self, z):
        # given random noise z, generate airfoils
        return self.dec(z)
```

```python
# train_vae.py

'''
train and test VAE model on airfoils
'''

import torch
import torch.nn as nn
from torch.utils.data import DataLoader
from torch.optim import Adam
import numpy as np
import torch.nn.functional as F

# from dataset import AirfoilDataset
# from vae import VAE
# from utils import *


def main():
    # check if cuda available
    device = 'cuda:0' if torch.cuda.is_available() else 'cpu'

    # define dataset and dataloader
    dataset = AirfoilDataset()
    airfoil_x = dataset.get_x()
    airfoil_dim = airfoil_x.shape[0]
    airfoil_dataloader = DataLoader(dataset, batch_size=16, shuffle=True)

    # hyperparameters
    latent_dim = 16 # please do not change latent dimension
    lr = 0.001      # learning rate
    num_epochs = 30

    # build the model
    vae = VAE(airfoil_dim=airfoil_dim, latent_dim=latent_dim).to(device)
    print("VAE model:\n", vae)

    # define your loss function here
    # loss = ?

    vae_loss = []

    def loss_function(x, recon_x, mu, std):
      BCE = F.mse_loss(recon_x, x.view(-1, 200), reduction='sum')
      KLD = -0.4 * torch.sum(1 + torch.log(std) - mu**2 - std**2)
      # dist = torch.normal(mu, logvar.exp())
      # norm = torch.randn_like(dist)
      # KLD = F.kl_div(dist, norm)
      return BCE + KLD

    # define optimizer for discriminator and generator separately
    optim = Adam(vae.parameters(), lr=lr, weight_decay=1e-5)

    # train the VAE model
    for epoch in range(num_epochs):
        for n_batch, (local_batch, __) in enumerate(airfoil_dataloader):
            y_real = local_batch.to(device)

            # train VAE

            # calculate customized VAE loss
            # loss = your_loss_func(...)

            optim.zero_grad()
            y_recon, mu, std = vae(y_real)

            loss = loss_function(y_real, y_recon, mu, std)

            loss.backward()
            optim.step()

            vae_loss.append(loss.item())
            # print loss while training
            if (n_batch + 1) % 30 == 0:
                print("Epoch: [{}/{}], Batch: {}, loss: {}".format(
                    epoch, num_epochs, n_batch, loss.item()))

    # test trained VAE model
    num_samples = 100

    # reconstuct airfoils
    real_airfoils = dataset.get_y()[:num_samples]
    recon_airfoils, __, __ = vae(torch.from_numpy(real_airfoils).to(device))
    if 'cuda' in device:
        recon_airfoils = recon_airfoils.detach().cpu().numpy()
    else:
        recon_airfoils = recon_airfoils.detach().numpy()

    # randomly synthesize airfoils
    noise = torch.randn((num_samples, latent_dim)).to(device)    # create random noise
    gen_airfoils = vae.decode(noise)
    if 'cuda' in device:
        gen_airfoils = gen_airfoils.detach().cpu().numpy()
    else:
        gen_airfoils = gen_airfoils.detach().numpy()

    # plot real/reconstructed/synthesized airfoils
```

```python
        # plot real/reconstructed/synthesized airfoils
        print("Original airfoils:")
        plot_airfoils(airfoil_x, real_airfoils)
        print("Reconstructed airfoils from originals:")
        plot_airfoils(airfoil_x, recon_airfoils)
        print("Generated airfoils from noise:")
        plot_airfoils(airfoil_x, gen_airfoils)

        plt.plot(vae_loss)
        plt.title("VAE Loss vs Epochs")
        plt.xlabel("Epoch")
        plt.ylabel("Loss")
        plt.show()


        save_path = './drive/MyDrive/24788-24789/code_q1_template/p1_vae_model.pth'
        torch.save(vae.state_dict(), save_path)

if __name__ == "__main__":
    main()
```

```
VAE model:
 VAE(
  (enc): Encoder(
    (model): Sequential(
      (0): Linear(in_features=200, out_features=128, bias=True)
      (1): ReLU()
      (2): Linear(in_features=128, out_features=64, bias=True)
      (3): ReLU()
      (4): Linear(in_features=64, out_features=32, bias=True)
      (5): ReLU()
    )
    (mean): Linear(in_features=32, out_features=16, bias=True)
    (std): Linear(in_features=32, out_features=16, bias=True)
  )
  (dec): Decoder(
    (model): Sequential(
      (0): Linear(in_features=16, out_features=32, bias=True)
      (1): ReLU()
      (2): Linear(in_features=32, out_features=64, bias=True)
      (3): ReLU()
      (4): Linear(in_features=64, out_features=128, bias=True)
      (5): ReLU()
      (6): Linear(in_features=128, out_features=200, bias=True)
      (7): Tanh()
    )
  )
)
Epoch: [0/30], Batch: 29, loss: 1.3400020599365234
Epoch: [0/30], Batch: 59, loss: 0.03232288360595703
Epoch: [0/30], Batch: 89, loss: -2.733518600463867
Epoch: [1/30], Batch: 29, loss: -5.794228553771973
Epoch: [1/30], Batch: 59, loss: -3.1250343322753906
Epoch: [1/30], Batch: 89, loss: 3.4426774978637695
Epoch: [2/30], Batch: 29, loss: 0.2861213684082031
Epoch: [2/30], Batch: 59, loss: -4.256100654602051
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Epoch: [3/30], Batch: 89, loss: -1.2670211791992188
Epoch: [4/30], Batch: 29, loss: -4.612958908081055
Epoch: [4/30], Batch: 59, loss: -2.0334653854370117
Epoch: [4/30], Batch: 89, loss: -3.838186264038086
Epoch: [5/30], Batch: 29, loss: 1.6018028259277344
Epoch: [5/30], Batch: 59, loss: -0.7306861877441406
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Epoch: [11/30], Batch: 29, loss: -5.0042724609375
Epoch: [11/30], Batch: 59, loss: -6.667401313781738
Epoch: [11/30], Batch: 89, loss: -4.5131025314331055
Epoch: [12/30], Batch: 29, loss: -2.993985176086426
Epoch: [12/30], Batch: 59, loss: -8.11329174041748
Epoch: [12/30], Batch: 89, loss: -4.541203498840332
Epoch: [13/30], Batch: 29, loss: -7.185236930847168
Epoch: [13/30], Batch: 59, loss: -1.2624807357788086
Epoch: [13/30], Batch: 89, loss: 0.35073089599609375
Epoch: [14/30], Batch: 29, loss: 0.32430362701416016
Epoch: [14/30], Batch: 59, loss: -4.645686149597168
Epoch: [14/30], Batch: 89, loss: -1.651834487915039
Epoch: [15/30], Batch: 29, loss: -0.1697835922241211
Epoch: [15/30], Batch: 59, loss: -2.759982109069824
Epoch: [15/30], Batch: 89, loss: -1.6457901000976562
Epoch: [16/30], Batch: 29, loss: -2.306818962097168
Epoch: [16/30], Batch: 59, loss: 2.488123893737793
```

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Epoch: [16/30], Batch: 89, loss: -3.70906925201416
Epoch: [17/30], Batch: 29, loss: 1.2054214477539062
Epoch: [17/30], Batch: 59, loss: -6.024144172668457
Epoch: [17/30], Batch: 89, loss: -3.5471200942993164
Epoch: [18/30], Batch: 29, loss: -1.7878026962280273
Epoch: [18/30], Batch: 59, loss: -3.03518009185791
Epoch: [18/30], Batch: 89, loss: 1.0510540008544922
Epoch: [19/30], Batch: 29, loss: -9.129096984863281
Epoch: [19/30], Batch: 59, loss: -6.809957504272461
Epoch: [19/30], Batch: 89, loss: 0.711918830871582
Epoch: [20/30], Batch: 29, loss: -1.7842121124267578
Epoch: [20/30], Batch: 59, loss: -7.841312885284424
Epoch: [20/30], Batch: 89, loss: -5.0486040115356445
Epoch: [21/30], Batch: 29, loss: 4.263511657714844
Epoch: [21/30], Batch: 59, loss: 3.204446792602539
Epoch: [21/30], Batch: 89, loss: -5.055760383605957
Epoch: [22/30], Batch: 29, loss: 5.09675407409668
Epoch: [22/30], Batch: 59, loss: 0.3405284881591797
Epoch: [22/30], Batch: 89, loss: -3.0603389739990234
Epoch: [23/30], Batch: 29, loss: -3.962489128112793
Epoch: [23/30], Batch: 59, loss: 1.0229434967041016
Epoch: [23/30], Batch: 89, loss: 3.4582529067993164
Epoch: [24/30], Batch: 29, loss: -8.731595039367676
Epoch: [24/30], Batch: 59, loss: -3.833315849304199
Epoch: [24/30], Batch: 89, loss: -1.291031837463379
Epoch: [25/30], Batch: 29, loss: -6.037304878234863
Epoch: [25/30], Batch: 59, loss: -2.4226913452148438
Epoch: [25/30], Batch: 89, loss: -4.999377250671387
Epoch: [26/30], Batch: 29, loss: -3.8611812591552734
Epoch: [26/30], Batch: 59, loss: -3.101034164428711
Epoch: [26/30], Batch: 89, loss: -2.098658561706543
Epoch: [27/30], Batch: 29, loss: 0.15855789184570312
Epoch: [27/30], Batch: 59, loss: -4.198464393615723
Epoch: [27/30], Batch: 89, loss: -0.2632160186767578
Epoch: [28/30], Batch: 29, loss: 0.4129199981689453
Epoch: [28/30], Batch: 59, loss: -2.3381147384643555
Epoch: [28/30], Batch: 89, loss: -5.880897521972656
Epoch: [29/30], Batch: 29, loss: -1.0484600067138672
Epoch: [29/30], Batch: 59, loss: -2.194502830505371
Epoch: [29/30], Batch: 89, loss: -6.291733741760254
Original airfoils:
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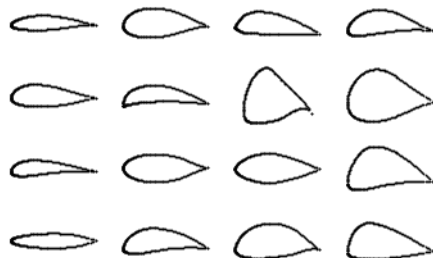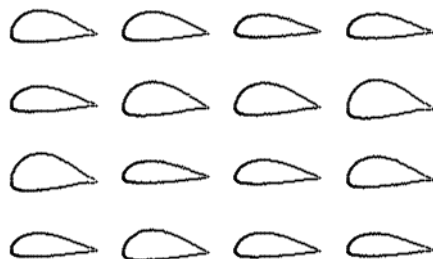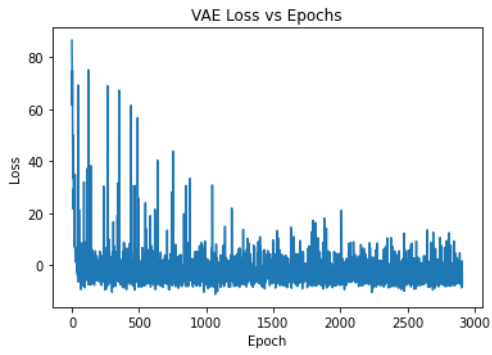


```
Reconstructed airfoils from originals:
```



```
Generated airfoils from noise:
```

VAE Loss vs Epochs

The VAE is able to produce cleaner airfoils than the GAN in this case, I tried some fine tuning of both models, but maybe the GAN could be further tuned to generate less noisy examples. Both still look like airfoils. The GAN results look noisier because the generator is creating them without any sort of reference for what a real airfoil would be, other than the discriminator's output. The VAE, on the other hand, is trained to decode gaussian distributions into airfoils, so the generated outputs look more consistent to the inputs.

The VAE seems to have trouble keeping the bottom of the airfoils consistent to the original images, all of the outputs seem to have similar bottoms, while the GAN has more varied generations.