[1]
```
from tensorflow.keras.datasets import mnist
import time
```

[2]
```
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```
```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11493376/11490434 [==============================] - 0s 0us/step
```

[3]
```
x_train = x_train / 127.5 - 1
x_test = x_test / 127.5 - 1
```

[4]
```
x_train.min(), x_train.max()
```
```
(-1.0, 1.0)
```

[5]
```
x_train = x_train.reshape(-1, 784)
x_train.shape
```
```
(60000, 784)
```

[6]
```
from tensorflow.keras.layers import Dense, LeakyReLU, Dropout, Input
from tensorflow.keras.models import Sequential, Model
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.initializers import RandomNormal
import numpy as np
import matplotlib.pyplot as plt
```

[7]
```
# gan에 입력되는 noise에 대한 dimension
NOISE_DIM = 10

# adam optimizer 정의, learning_rate = 0.0002, beta_1로 줍니다.
# Vanilla Gan과 DCGAN에서 이렇게 셋팅을 해주는데
# 이렇게 해줘야 좋은 학습을 잘합니다.
adam = Adam(lr=0.0002, beta_1=0.5)
```
```
/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/optimizer_v2/optimizer_v2.py:375: UserWarning: The `lr` argument is deprecated, use `learning_rate` instead.
  "The `lr` argument is deprecated, use `learning_rate` instead.")
```

[8]
```
generator = Sequential([
    Dense(256, input_dim=NOISE_DIM),
    LeakyReLU(0.2),
    Dense(28*28, activation='tanh'),
])
```

[9]
```
generator.summary()
```
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 256)               2816
_________________________________________________________________
leaky_re_lu (LeakyReLU)      (None, 256)               0
_________________________________________________________________
dense_1 (Dense)              (None, 784)               201488
=================================================================
Total params: 204,304
Trainable params: 204,304
Non-trainable params: 0
_________________________________________________________________
```

[10]
```
discriminator = Sequential([
    Dense(256, input_shape=(784,), kernel_initializer=RandomNormal(stddev=0.02)),
    LeakyReLU(0.2),
    Dropout(0.3),
    Dense(1, activation='sigmoid')
])
```

[11]
```
discriminator.summary()
```
```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_2 (Dense)              (None, 256)               200960
_________________________________________________________________
leaky_re_lu_1 (LeakyReLU)    (None, 256)               0
_________________________________________________________________
dropout (Dropout)            (None, 256)               0
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 257
=================================================================
Total params: 201,217
Trainable params: 201,217
Non-trainable params: 0
_________________________________________________________________
```

[12]
```
discriminator.compile(loss='binary_crossentropy', optimizer=adam)
```

[13]
```
# discriminator는 학습을 하지 않도록 하며, Gan 모델에서는 generator만 학습하도록 합니다.
discriminator.trainable = False
gan_input = Input(shape=(NOISE_DIM,))
x = generator(inputs=gan_input)
output = discriminator(x)
```

[14]
```
gan = Model(gan_input, output)
```

[15]
```
gan.summary()
```
```
Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 10)]              0
_________________________________________________________________
sequential (Sequential)      (None, 784)               204304
_________________________________________________________________
sequential_1 (Sequential)    (None, 1)                 201217
=================================================================
Total params: 405,521
Trainable params: 204,304
Non-trainable params: 201,217
_________________________________________________________________
```

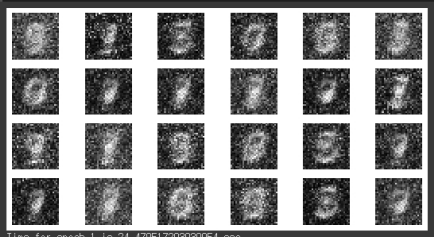
[16]
```
gan.compile(loss='binary_crossentropy', optimizer=adam)
```

[17]
```
def get_batches(data, batch_size):
    batches = []
    for i in range(int(data.shape[0] // batch_size)):
        batch = data[i * batch_size: (i + 1) * batch_size]
        batches.append(batch)
    return np.asarray(batches)
```

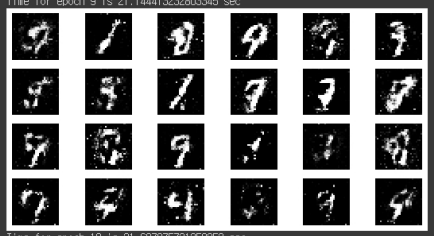
[18]
```
def visualize_training(epoch, d_losses, g_losses):
    '''
    # 오차에 대한 시각화
    plt.figure(figsize=(8, 4))
    plt.plot(d_losses, label='Discriminator Loss')
    plt.plot(g_losses, label='Generatror Loss')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.legend()
    plt.show()

    print('epoch: {}, Discriminator Loss: {}, Generator Loss: {}'.format(epoch, np.asarray(d_losses).mean(), np.asarray(g_losses).mean()))
    '''
    #샘플 데이터 생성 후 시각화
    noise = np.random.normal(0, 1, size=(24, NOISE_DIM))
    generated_images = generator.predict(noise)
    generated_images = generated_images.reshape(-1, 28, 28)

    plt.figure(figsize=(8, 4))
    for i in range(generated_images.shape[0]):
        plt.subplot(4, 6, i+1)
        plt.imshow(generated_images[i], interpolation='nearest', cmap='gray')
        plt.axis('off')
    plt.tight_layout()
    plt.show()
```

[19]
```
BATCH_SIZE = 128
EPOCHS= 10
```

```
# discriminator와 gan 모델의 loss 측정을 위한 list 입니다.
d_losses = []
g_losses = []

for epoch in range(1, EPOCHS + 1):
    start = time.time()

    # 각 배치별 학습
    for real_images in get_batches(x_train, BATCH_SIZE):
        # 랜덤 노이즈 생성
        input_noise = np.random.uniform(-1, 1, size=[BATCH_SIZE, NOISE_DIM])

        # 가짜 이미지 데이터 생성
        generated_images = generator.predict(input_noise)

        # Gan에 학습할 X 데이터 정의
        x_dis = np.concatenate([real_images, generated_images])

        # Gan에 학습할 Y 데이터 정의
        y_dis = np.zeros(2 * BATCH_SIZE)
        y_dis[:BATCH_SIZE] = 0.9

        # Discriminator 훈련
        discriminator.trainable = True
        d_loss = discriminator.train_on_batch(x_dis, y_dis)

        # Gan 훈련
        noise = np.random.uniform(-1, 1, size=[BATCH_SIZE, NOISE_DIM])
        y_gan = np.ones(BATCH_SIZE)

        # Discriminator의 판별 학습을 방지합니다
        discriminator.trainable = False
        g_loss = gan.train_on_batch(noise, y_gan)

    d_losses.append(d_loss)
    g_losses.append(g_loss)

    if epoch == 1 or epoch % 10 == 0:
        visualize_training(epoch, d_losses, g_losses)

    # print (' 에포크 {} 에서 걸린 시간은 {} 초 입니다'.format(epoch +1, time.time()-start))
    print ('Time for epoch {} is {} sec'.format(epoch, time.time()-start))
```



```
Time for epoch 1 is 24.478517293930054 sec
Time for epoch 2 is 20.316551685333252 sec
Time for epoch 3 is 20.144975662231445 sec
Time for epoch 4 is 21.516667842864990 sec
Time for epoch 5 is 20.590003967285156 sec
Time for epoch 6 is 20.248979330062866 sec
Time for epoch 7 is 20.208998394953003 sec
Time for epoch 8 is 20.445534229278564 sec
Time for epoch 9 is 21.144413232803345 sec
```



```
Time for epoch 10 is 21.607975721359253 sec
```


3분 30초 오후 4:42에 완료됨