```
import tensorflow as tf

tf.__version__

{"type":"string"}

import glob
import imageio
import matplotlib.pyplot as plt
import numpy as np
import os
import PIL
from tensorflow.keras import layers
import time

from IPython import display
```

Using MNIST dataset for the model

```
(train_images, train_labels), (_, _) =
tf.keras.datasets.mnist.load_data()

train_images = train_images.reshape(train_images.shape[0], 28, 28,
1).astype('float32')
train_images = (train_images - 127.5) / 127.5  # Normalize the images
to [-1, 1]

BUFFER_SIZE = 60000
BATCH_SIZE = 256

# Batch and shuffle the data
train_dataset =
tf.data.Dataset.from_tensor_slices(train_images).shuffle(BUFFER_SIZE).
batch(BATCH_SIZE)
```

Defining the generator and the discrminator

```
def make_generator_model():
    model = tf.keras.Sequential()
    model.add(layers.Dense(7*7*256, use_bias=False,
input_shape=(100,)))
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Reshape((7, 7, 256)))
    assert model.output_shape == (None, 7, 7, 256)  # Note: None is
the batch size

    model.add(layers.Conv2DTranspose(128, (5, 5), strides=(1, 1),
padding='same', use_bias=False))
```

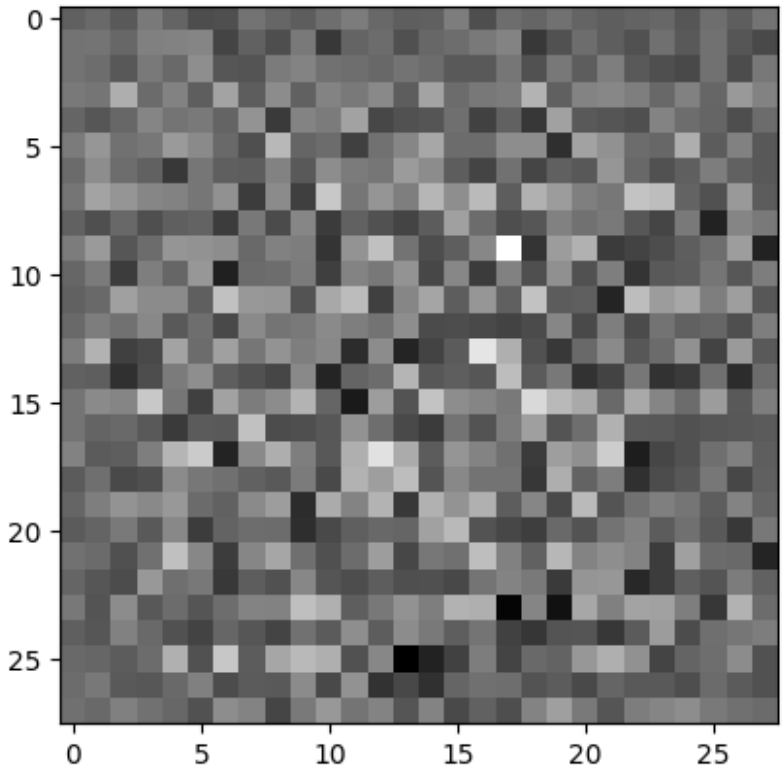
```
    assert model.output_shape == (None, 7, 7, 128)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(64, (5, 5), strides=(2, 2),
padding='same', use_bias=False))
    assert model.output_shape == (None, 14, 14, 64)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(1, (5, 5), strides=(2, 2),
padding='same', use_bias=False, activation='tanh'))
    assert model.output_shape == (None, 28, 28, 1)

    return model
```

Using the generator to create an image.

```
generator = make_generator_model()

noise = tf.random.normal([1, 100])
generated_image = generator(noise, training=False)

plt.imshow(generated_image[0, :, :, 0], cmap='gray')
generator.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_4 (Dense)             (None, 12544)             1254400

 batch_normalization_7 (Bat  (None, 12544)             50176
 chNormalization)

 leaky_re_lu_12 (LeakyReLU)  (None, 12544)             0

 reshape_2 (Reshape)         (None, 7, 7, 256)         0

 conv2d_transpose_7 (Conv2D  (None, 7, 7, 128)         819200
 Transpose)

 batch_normalization_8 (Bat  (None, 7, 7, 128)         512
 chNormalization)

 leaky_re_lu_13 (LeakyReLU)  (None, 7, 7, 128)         0

 conv2d_transpose_8 (Conv2D  (None, 14, 14, 64)        204800
 Transpose)
```

```
 batch_normalization_9 (Bat  (None, 14, 14, 64)        256
 chNormalization)

 leaky_re_lu_14 (LeakyReLU)  (None, 14, 14, 64)        0

 conv2d_transpose_9 (Conv2D  (None, 28, 28, 1)         1600
 Transpose)

=================================================================
Total params: 2330944 (8.89 MB)
Trainable params: 2305472 (8.79 MB)
Non-trainable params: 25472 (99.50 KB)
_________________________________________________________________
```



Using CNN based discriminator

```
def make_discriminator_model():
    model = tf.keras.Sequential()
    model.add(layers.Conv2D(64, (5, 5), strides=(2, 2),
padding='same',
                                     input_shape=[28, 28, 1]))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Conv2D(128, (5, 5), strides=(2, 2),
```

```
padding='same'))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Flatten())
    model.add(layers.Dense(1))

    return model
```

Use the (as yet untrained) discriminator to classify the generated images as real or fake. The model will be trained to output positive values for real images, and negative values for fake images.

```
discriminator = make_discriminator_model()
decision = discriminator(generated_image)
print (decision)
discriminator.summary()
```

```
tf.Tensor([[0.00122182]], shape=(1, 1), dtype=float32)
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 14, 14, 64)        1664

 leaky_re_lu_15 (LeakyReLU)  (None, 14, 14, 64)        0

 dropout_5 (Dropout)         (None, 14, 14, 64)        0

 conv2d_6 (Conv2D)           (None, 7, 7, 128)         204928

 leaky_re_lu_16 (LeakyReLU)  (None, 7, 7, 128)         0

 dropout_6 (Dropout)         (None, 7, 7, 128)         0

 flatten_2 (Flatten)         (None, 6272)              0

 dense_5 (Dense)             (None, 1)                 6273

=================================================================
Total params: 212865 (831.50 KB)
Trainable params: 212865 (831.50 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Defining the loss functions and optimizers for both models

```
# This method returns a helper function to compute cross entropy loss
cross_entropy = tf.keras.losses.BinaryCrossentropy(from_logits=True)
```

```
def discriminator_loss(real_output, fake_output):
    real_loss = cross_entropy(tf.ones_like(real_output), real_output)
    fake_loss = cross_entropy(tf.zeros_like(fake_output), fake_output)
    total_loss = real_loss + fake_loss
    return total_loss

def generator_loss(fake_output):
    return cross_entropy(tf.ones_like(fake_output), fake_output)

generator_optimizer = tf.keras.optimizers.Adam(1e-4)
discriminator_optimizer = tf.keras.optimizers.Adam(1e-4)
```

Saving the checkpoints

```
checkpoint_dir = './training_checkpoints'
checkpoint_prefix = os.path.join(checkpoint_dir, "ckpt")
checkpoint =
tf.train.Checkpoint(generator_optimizer=generator_optimizer,

discriminator_optimizer=discriminator_optimizer,
                                 generator=generator,
                                 discriminator=discriminator)
```

Defining the training loop and setting the hyperparameters

```
EPOCHS = 50
noise_dim = 100
num_examples_to_generate = 16

# You will reuse this seed overtime (so it's easier)
# to visualize progress in the animated GIF)
seed = tf.random.normal([num_examples_to_generate, noise_dim])
```

Using random seed as input

```
# Notice the use of `tf.function`
# This annotation causes the function to be "compiled".
@tf.function
def train_step(images):
    noise = tf.random.normal([BATCH_SIZE, noise_dim])

    with tf.GradientTape() as gen_tape, tf.GradientTape() as
disc_tape:
      generated_images = generator(noise, training=True)

      real_output = discriminator(images, training=True)
      fake_output = discriminator(generated_images, training=True)

      gen_loss = generator_loss(fake_output)
```

```
      disc_loss = discriminator_loss(real_output, fake_output)

    gradients_of_generator = gen_tape.gradient(gen_loss,
generator.trainable_variables)
    gradients_of_discriminator = disc_tape.gradient(disc_loss,
discriminator.trainable_variables)

    generator_optimizer.apply_gradients(zip(gradients_of_generator,
generator.trainable_variables))

discriminator_optimizer.apply_gradients(zip(gradients_of_discriminator
, discriminator.trainable_variables))
    return gen_loss, disc_loss

def train(dataset, epochs):
  gen_losses = []
  disc_losses = []
  for epoch in range(epochs):
    start = time.time()

    for image_batch in dataset:
      gen_loss, disc_loss = train_step(image_batch)

    gen_losses.append(gen_loss)
    disc_losses.append(disc_loss)

    #print(f'Epoch {epoch+1}, Generator Loss: {gen_loss},
Discriminator Loss: {disc_loss}')



    # Produce images for the GIF as you go
    display.clear_output(wait=True)
    generate_and_save_images(generator,
                             epoch + 1,
                             seed)

    # Save the model every 15 epochs
    if (epoch + 1) % 15 == 0:
      checkpoint.save(file_prefix = checkpoint_prefix)

    print ('Time for epoch {} is {} sec'.format(epoch + 1,
time.time()-start))

  # Generate after the final epoch
  display.clear_output(wait=True)
  generate_and_save_images(generator,
                           epochs,
                           seed)
```

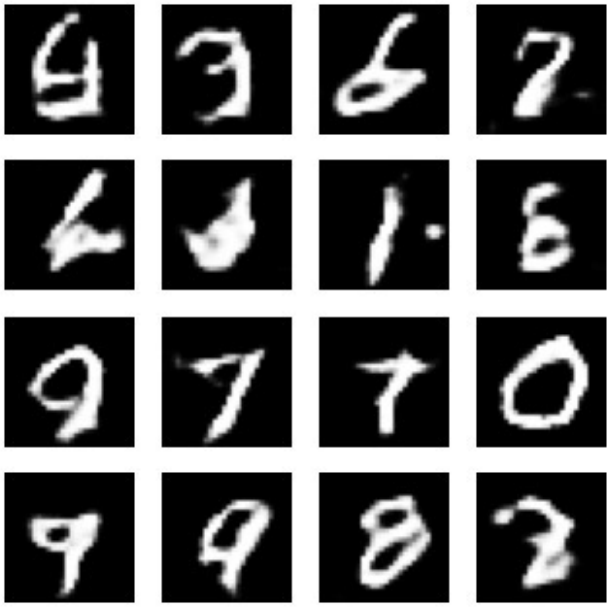
```
   # Plot the losses
  plt.figure(figsize=(10, 5))
  plt.plot(gen_losses, label='Generator Loss')
  plt.plot(disc_losses, label='Discriminator Loss')
  plt.xlabel('Epochs')
  plt.ylabel('Loss')
  plt.legend()
  plt.title('Generator and Discriminator Loss During Training')
  plt.show()

  # Print minimum errors observed
  print(f'Minimum Generator Loss: {min(gen_losses)}')
  print(f'Minimum Discriminator Loss: {min(disc_losses)}')
```

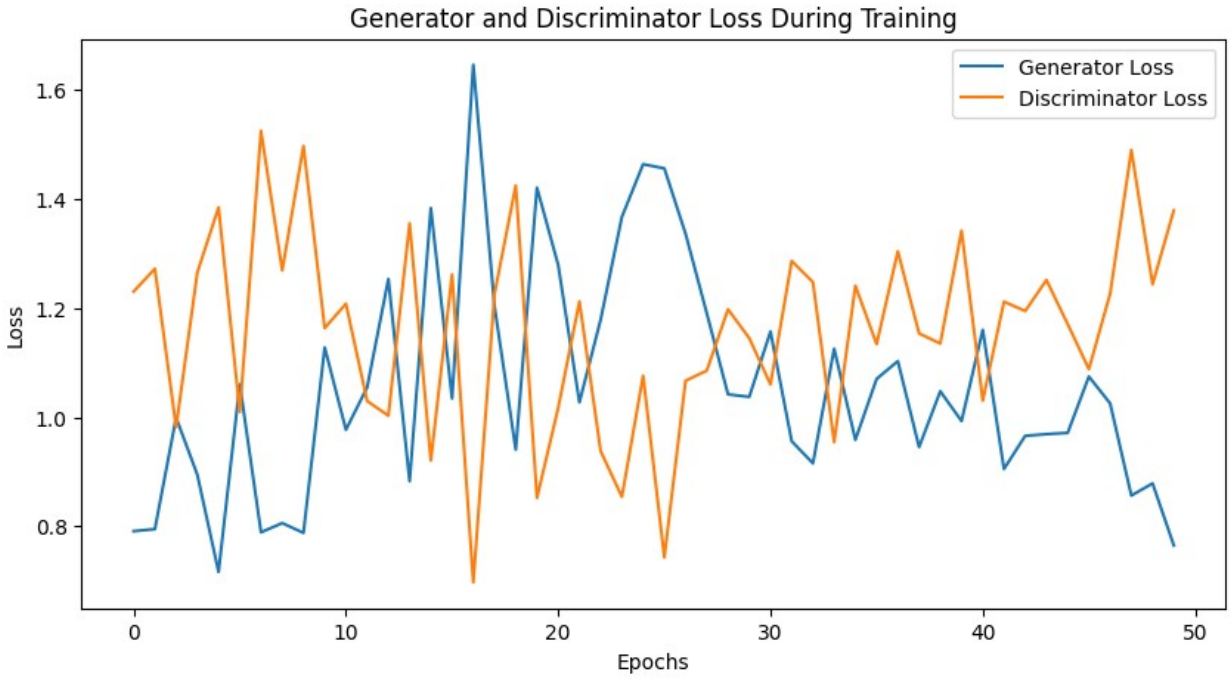
Generating and saving images

```
def generate_and_save_images(model, epoch, test_input):
  # Notice `training` is set to False.
  # This is so all layers run in inference mode (batchnorm).
  predictions = model(test_input, training=False)

  fig = plt.figure(figsize=(4, 4))

  for i in range(predictions.shape[0]):
      plt.subplot(4, 4, i+1)
      plt.imshow(predictions[i, :, :, 0] * 127.5 + 127.5, cmap='gray')
      plt.axis('off')

  plt.savefig('image_at_epoch_{:04d}.png'.format(epoch))
  plt.show()
```

Training and plotting the graph of the loss curves

```
train(train_dataset, EPOCHS)
```






```
Minimum Generator Loss: 0.7165205478668213
Minimum Discriminator Loss: 0.697304368019104
```

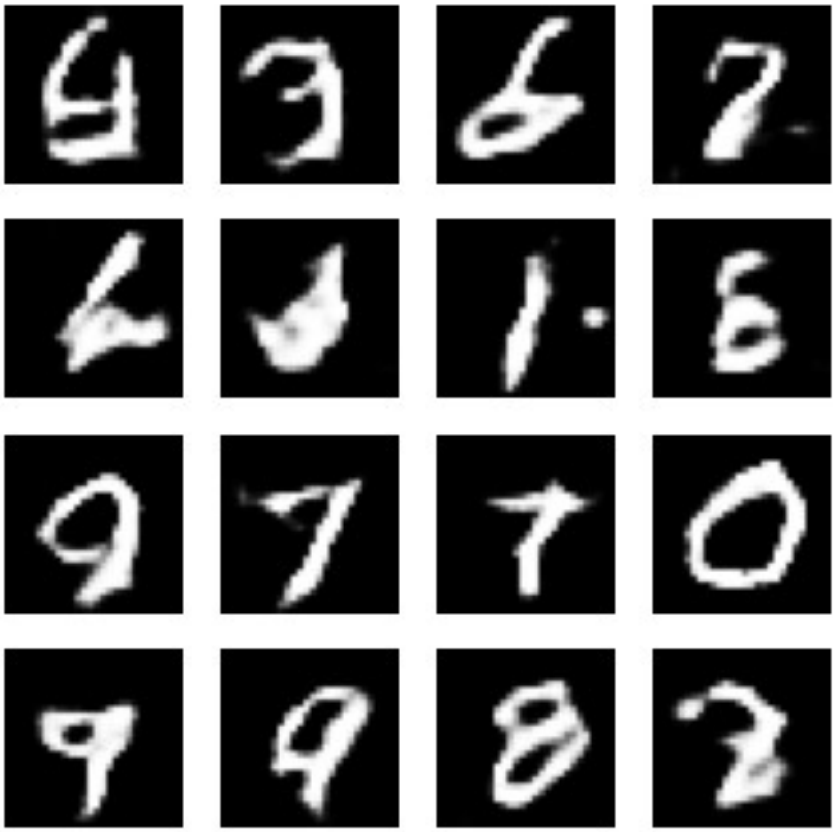
Restore the latest checkpoint.

```
checkpoint.restore(tf.train.latest_checkpoint(checkpoint_dir))
```

```
<tensorflow.python.checkpoint.checkpoint.CheckpointLoadStatus at
0x7c9506054040>
```

Creating a GIF

```
# Display a single image using the epoch number
def display_image(epoch_no):
  return PIL.Image.open('image_at_epoch_{:04d}.png'.format(epoch_no))

display_image(EPOCHS)
```



Use `imageio` to create an animated gif using the images saved during training.

```
anim_file = 'dcgan.gif'

with imageio.get_writer(anim_file, mode='I') as writer:
  filenames = glob.glob('image*.png')
  filenames = sorted(filenames)
  for filename in filenames:
    image = imageio.imread(filename)
    writer.append_data(image)
```

```
  image = imageio.imread(filename)
  writer.append_data(image)
```

```
<ipython-input-82-56bb6d34be2e>:7: DeprecationWarning: Starting with
ImageIO v3 the behavior of this function will switch to that of
iio.v3.imread. To keep the current behavior (and make this warning
disappear) use `import imageio.v2 as imageio` or call
`imageio.v2.imread` directly.
  image = imageio.imread(filename)
<ipython-input-82-56bb6d34be2e>:9: DeprecationWarning: Starting with
ImageIO v3 the behavior of this function will switch to that of
iio.v3.imread. To keep the current behavior (and make this warning
disappear) use `import imageio.v2 as imageio` or call
`imageio.v2.imread` directly.
  image = imageio.imread(filename)
```

```
!pip install git+https://github.com/tensorflow/docs
```

```
Collecting git+https://github.com/tensorflow/docs
  Cloning https://github.com/tensorflow/docs to /tmp/pip-req-build-
xoqrbn5_
  Running command git clone --filter=blob:none --quiet
https://github.com/tensorflow/docs /tmp/pip-req-build-xoqrbn5_
  Resolved https://github.com/tensorflow/docs to commit
75b2672b5bed8ca0995663536db84bd9a39b8896
  Preparing metadata (setup.py) ... ent already satisfied: astor in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (0.8.1)
Requirement already satisfied: absl-py in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (1.4.0)
Requirement already satisfied: jinja2 in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (3.1.4)
Requirement already satisfied: nbformat in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (5.10.4)
Requirement already satisfied: protobuf>=3.12 in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (3.20.3)
Requirement already satisfied: pyyaml in
/usr/local/lib/python3.10/dist-packages (from tensorflow-
docs==2024.5.3.31743) (6.0.1)
Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.10/dist-packages (from jinja2->tensorflow-
docs==2024.5.3.31743) (2.1.5)
Requirement already satisfied: fastjsonschema>=2.15 in
/usr/local/lib/python3.10/dist-packages (from nbformat->tensorflow-
docs==2024.5.3.31743) (2.20.0)
Requirement already satisfied: jsonschema>=2.6 in
```

```
/usr/local/lib/python3.10/dist-packages (from nbformat->tensorflow-
docs==2024.5.3.31743) (4.19.2)
Requirement already satisfied: jupyter-core!=5.0.*,>=4.12 in
/usr/local/lib/python3.10/dist-packages (from nbformat->tensorflow-
docs==2024.5.3.31743) (5.7.2)
Requirement already satisfied: traitlets>=5.1 in
/usr/local/lib/python3.10/dist-packages (from nbformat->tensorflow-
docs==2024.5.3.31743) (5.7.1)
Requirement already satisfied: attrs>=22.2.0 in
/usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6-
>nbformat->tensorflow-docs==2024.5.3.31743) (23.2.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in
/usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6-
>nbformat->tensorflow-docs==2024.5.3.31743) (2023.12.1)
Requirement already satisfied: referencing>=0.28.4 in
/usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6-
>nbformat->tensorflow-docs==2024.5.3.31743) (0.35.1)
Requirement already satisfied: rpds-py>=0.7.1 in
/usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6-
>nbformat->tensorflow-docs==2024.5.3.31743) (0.18.1)
Requirement already satisfied: platformdirs>=2.5 in
/usr/local/lib/python3.10/dist-packages (from jupyter-core!
=5.0.*,>=4.12->nbformat->tensorflow-docs==2024.5.3.31743) (4.2.2)

import tensorflow_docs.vis.embed as embed
embed.embed_file(anim_file)

<IPython.core.display.HTML object>
```

##Improving the model

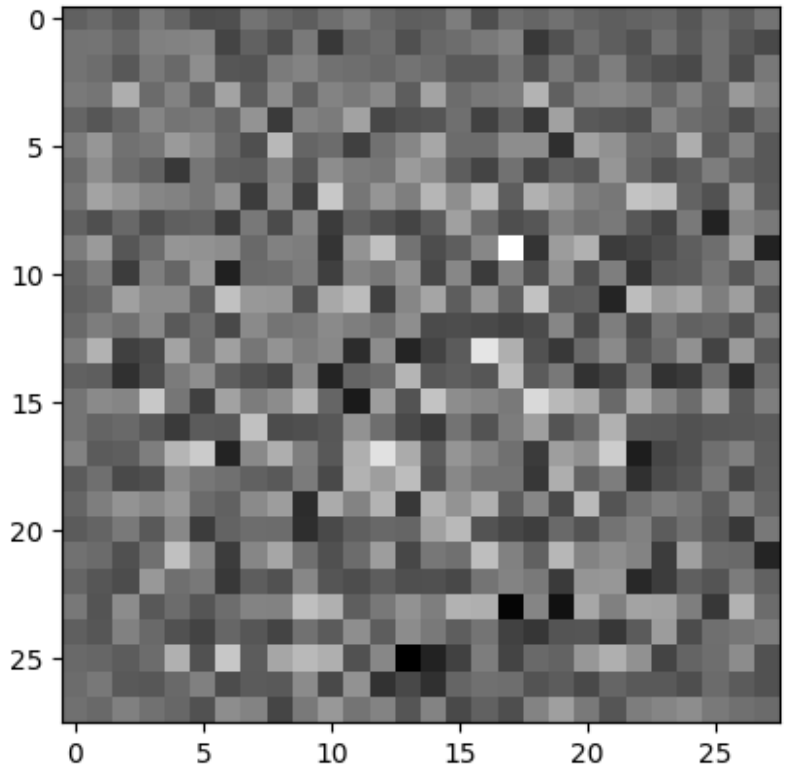
Defining the new Generator and Discriminator

```
def make_generator_model_2():
    model = tf.keras.Sequential()
    model.add(layers.Dense(7*7*256, use_bias=False,
input_shape=(100,)))
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Reshape((7, 7, 256)))
    assert model.output_shape == (None, 7, 7, 256)  # Note: None is
the batch size

    model.add(layers.Conv2DTranspose(128, (5, 5), strides=(1, 1),
padding='same', use_bias=False))
    assert model.output_shape == (None, 7, 7, 128)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())
```

```
    model.add(layers.Conv2DTranspose(64, (5, 5), strides=(2, 2),
padding='same', use_bias=False))
    assert model.output_shape == (None, 14, 14, 64)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(32, (5, 5), strides=(1, 1),
padding='same', use_bias=False))
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(1, (5, 5), strides=(2, 2),
padding='same', use_bias=False, activation='tanh'))
    assert model.output_shape == (None, 28, 28, 1)

    return model

new_generator = make_generator_model_2()
new_generator.summary()

noise = tf.random.normal([1, 100])
new_generated_image = new_generator(noise, training=False)

plt.imshow(generated_image[0, :, :, 0], cmap='gray')
```

```
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             (None, 12544)             1254400

 batch_normalization_10 (Ba  (None, 12544)             50176
 tchNormalization)

 leaky_re_lu_17 (LeakyReLU)  (None, 12544)             0

 reshape_3 (Reshape)         (None, 7, 7, 256)         0

 conv2d_transpose_10 (Conv2  (None, 7, 7, 128)         819200
 DTranspose)

 batch_normalization_11 (Ba  (None, 7, 7, 128)         512
 tchNormalization)

 leaky_re_lu_18 (LeakyReLU)  (None, 7, 7, 128)         0

 conv2d_transpose_11 (Conv2  (None, 14, 14, 64)        204800
 DTranspose)

 batch_normalization_12 (Ba  (None, 14, 14, 64)        256
```

```
 tchNormalization)

 leaky_re_lu_19 (LeakyReLU)  (None, 14, 14, 64)        0

 conv2d_transpose_12 (Conv2  (None, 14, 14, 32)        51200
 DTranspose)

 batch_normalization_13 (Ba  (None, 14, 14, 32)        128
 tchNormalization)

 leaky_re_lu_20 (LeakyReLU)  (None, 14, 14, 32)        0

 conv2d_transpose_13 (Conv2  (None, 28, 28, 1)         800
 DTranspose)

=================================================================
Total params: 2381472 (9.08 MB)
Trainable params: 2355936 (8.99 MB)
Non-trainable params: 25536 (99.75 KB)
_________________________________________________________________

<matplotlib.image.AxesImage at 0x7c95e84c1f00>
```




```python
def make_discriminator_model_2():
    model = tf.keras.Sequential()
```

```
    model.add(layers.Conv2D(128, (5, 5), strides=(2, 2),
padding='same', input_shape=[28, 28, 1]))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Conv2D(256, (5, 5), strides=(2, 2),
padding='same'))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Conv2D(512, (5, 5), strides=(2, 2),
padding='same'))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Flatten())
    model.add(layers.Dense(1))

    return model

new_discriminator = make_discriminator_model_2()
decision = new_discriminator(new_generated_image)
print (decision)
new_discriminator.summary()
```

```
tf.Tensor([[-0.00077103]], shape=(1, 1), dtype=float32)
Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_7 (Conv2D)           (None, 14, 14, 128)       3328

 leaky_re_lu_21 (LeakyReLU)  (None, 14, 14, 128)       0

 dropout_7 (Dropout)         (None, 14, 14, 128)       0

 conv2d_8 (Conv2D)           (None, 7, 7, 256)         819456

 leaky_re_lu_22 (LeakyReLU)  (None, 7, 7, 256)         0

 dropout_8 (Dropout)         (None, 7, 7, 256)         0

 conv2d_9 (Conv2D)           (None, 4, 4, 512)         3277312

 leaky_re_lu_23 (LeakyReLU)  (None, 4, 4, 512)         0

 dropout_9 (Dropout)         (None, 4, 4, 512)         0

 flatten_3 (Flatten)         (None, 8192)              0
```

```
 dense_7 (Dense)             (None, 1)                 8193

=================================================================
Total params: 4108289 (15.67 MB)
Trainable params: 4108289 (15.67 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
new_generator_optimizer = tf.keras.optimizers.Adam(1e-4)
new_discriminator_optimizer = tf.keras.optimizers.Adam(1e-4)
new_generator_optimizer.build(new_generator.trainable_variables)
new_discriminator_optimizer.build(new_discriminator.trainable_variable
s)
```

new checkpoints

```
checkpoint_dir = './training_checkpoints_2'
checkpoint_prefix = os.path.join(checkpoint_dir, "ckpt")
checkpoint = tf.train.Checkpoint(generator_optimizer=
new_generator_optimizer,
                                 discriminator_optimizer=
new_discriminator_optimizer,
                                 generator= new_generator,
                                 discriminator= new_discriminator)
```

Changing the functions

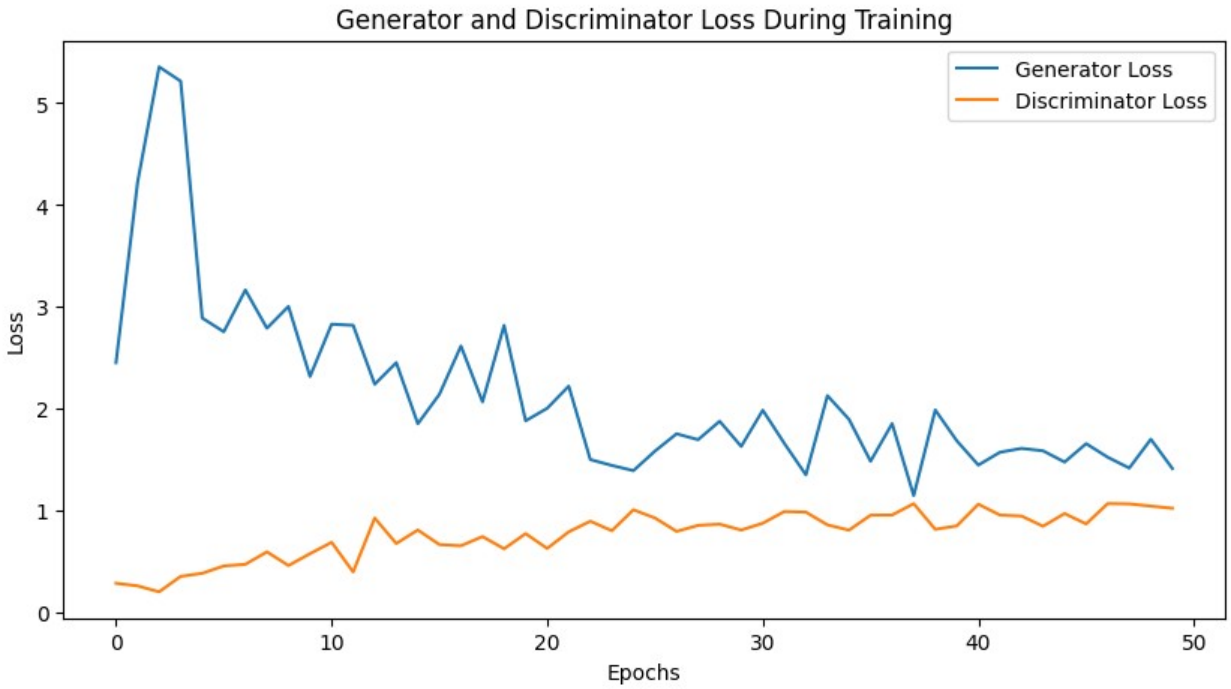
```
@tf.function
def train_step_again(images):
    noise = tf.random.normal([BATCH_SIZE, noise_dim])

    with tf.GradientTape() as gen_tape, tf.GradientTape() as
disc_tape:
      generated_images = new_generator(noise, training=True)

      real_output = new_discriminator(images, training=True)
      fake_output = new_discriminator(generated_images, training=True)

      gen_loss = generator_loss(fake_output)
      disc_loss = discriminator_loss(real_output, fake_output)

    gradients_of_generator = gen_tape.gradient(gen_loss,
new_generator.trainable_variables)
    gradients_of_discriminator = disc_tape.gradient(disc_loss,
new_discriminator.trainable_variables)


new_generator_optimizer.apply_gradients(zip(gradients_of_generator,
new_generator.trainable_variables))
```

```
new_discriminator_optimizer.apply_gradients(zip(gradients_of_discrimin
ator, new_discriminator.trainable_variables))
    return gen_loss, disc_loss

def generate_and_save_images_2(model, epoch, test_input):

  predictions = model(test_input, training=False)

  fig = plt.figure(figsize=(4, 4))

  for i in range(predictions.shape[0]):
      plt.subplot(4, 4, i+1)
      plt.imshow(predictions[i, :, :, 0] * 127.5 + 127.5, cmap='gray')
      plt.axis('off')

  plt.savefig('new_model_image_at_epoch_{:04d}.png'.format(epoch))
  plt.show()

def train_again(dataset, epochs):
  gen_losses = []
  disc_losses = []
  for epoch in range(epochs):
    start = time.time()

    for image_batch in dataset:
      gen_loss, disc_loss = train_step_again(image_batch)

    gen_losses.append(gen_loss)
    disc_losses.append(disc_loss)

    #print(f'Epoch {epoch+1}, Generator Loss: {gen_loss},
Discriminator Loss: {disc_loss}')



    # Produce images for the GIF as you go
    display.clear_output(wait=True)
    generate_and_save_images_2(new_generator,
                               epoch + 1,
                               seed)

    # Save the model every 15 epochs
    if (epoch + 1) % 15 == 0:
      checkpoint.save(file_prefix = checkpoint_prefix)

    print ('Time for epoch {} is {} sec'.format(epoch + 1,
time.time()-start))

  # Generate after the final epoch
```

```
  display.clear_output(wait=True)
  generate_and_save_images_2(new_generator,
                             epochs,
                             seed)

   # Plot the losses
  plt.figure(figsize=(10, 5))
  plt.plot(gen_losses, label='Generator Loss')
  plt.plot(disc_losses, label='Discriminator Loss')
  plt.xlabel('Epochs')
  plt.ylabel('Loss')
  plt.legend()
  plt.title('Generator and Discriminator Loss During Training')
  plt.show()

  # Print minimum errors observed
  print(f'Minimum Generator Loss: {min(gen_losses)}')
  print(f'Minimum Discriminator Loss: {min(disc_losses)}')
```

Training the model

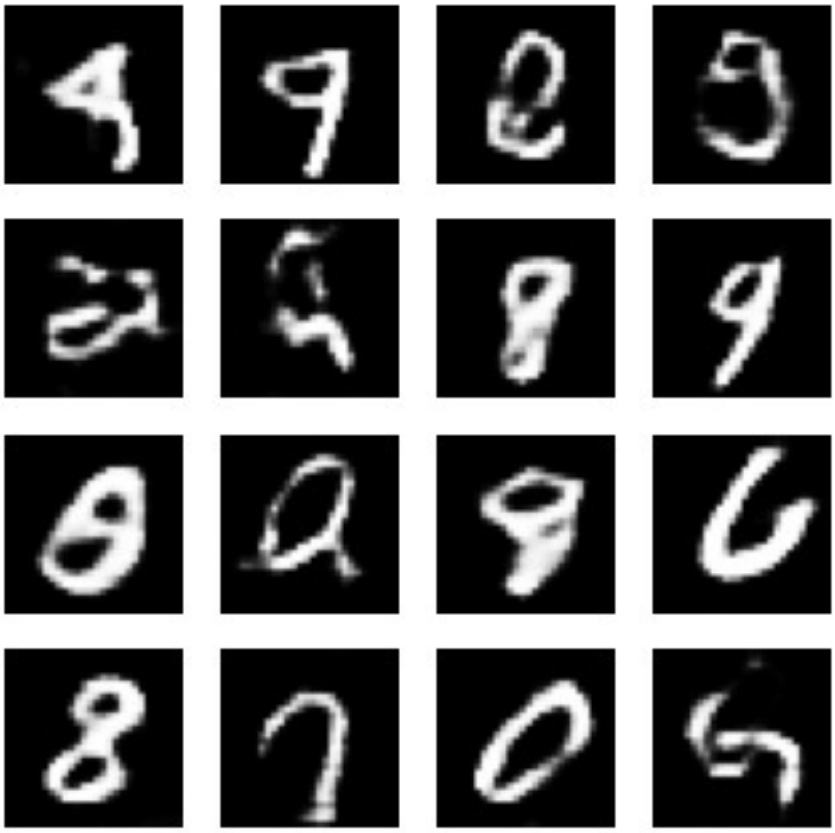
```
train_again(train_dataset, EPOCHS)
```




```
Minimum Generator Loss: 1.1488616466522217
Minimum Discriminator Loss: 0.20459893345832825
```

Displaying the image and creating GIF for the improved model

```
def display_image_2(epoch_no):
  return
PIL.Image.open('new_model_image_at_epoch_{:04d}.png'.format(epoch_no))

display_image_2(EPOCHS)
```



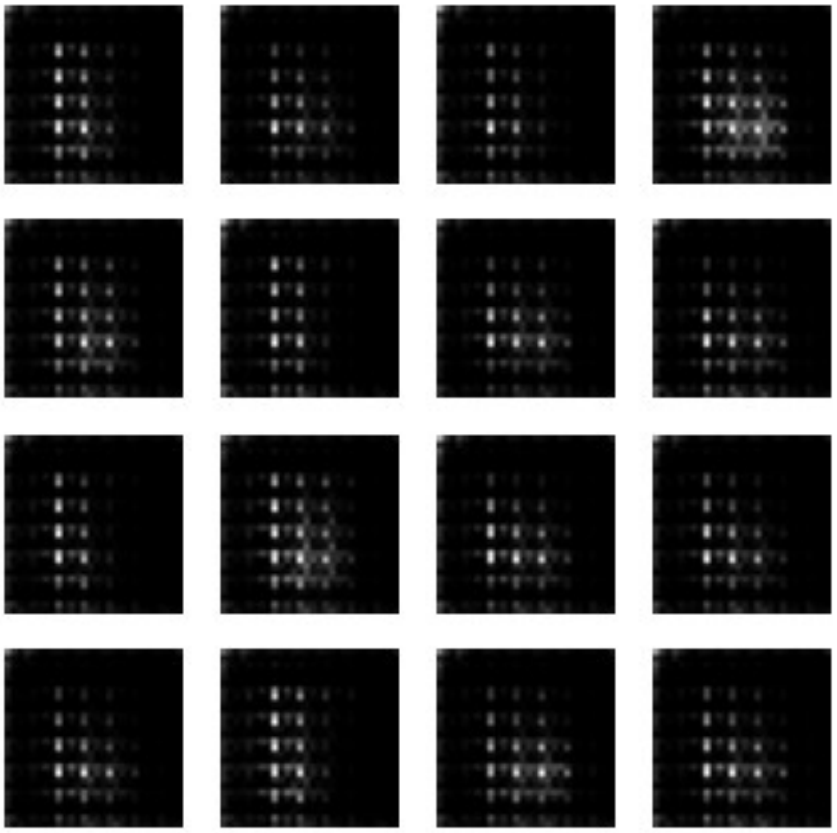
```
anim_file_2 = 'dcgan2.gif'

with imageio.get_writer(anim_file_2, mode='I') as writer:
  filenames = glob.glob('new_model*.png')
  filenames = sorted(filenames)
  for filename in filenames:
    image = imageio.imread(filename)
    writer.append_data(image)
  image = imageio.imread(filename)
  writer.append_data(image)
```

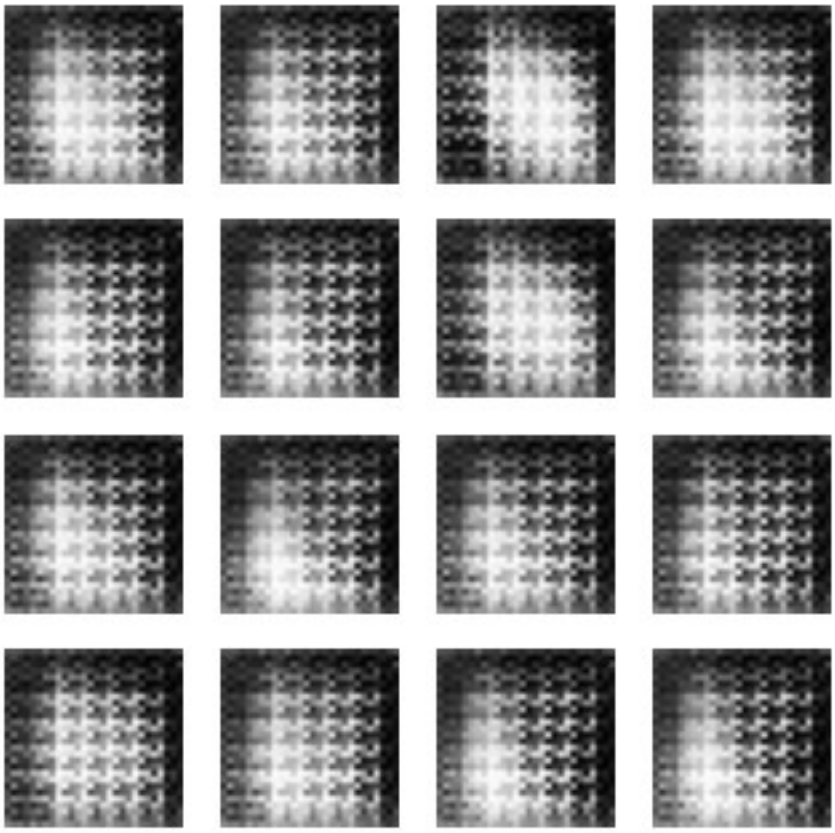
```
<ipython-input-101-921dc1a49172>:7: DeprecationWarning: Starting with
ImageIO v3 the behavior of this function will switch to that of
iio.v3.imread. To keep the current behavior (and make this warning
disappear) use `import imageio.v2 as imageio` or call
`imageio.v2.imread` directly.
  image = imageio.imread(filename)
<ipython-input-101-921dc1a49172>:9: DeprecationWarning: Starting with
```

```
ImageIO v3 the behavior of this function will switch to that of
iio.v3.imread. To keep the current behavior (and make this warning
disappear) use `import imageio.v2 as imageio` or call
`imageio.v2.imread` directly.
  image = imageio.imread(filename)

embed.embed_file(anim_file_2)

<IPython.core.display.HTML object>
```

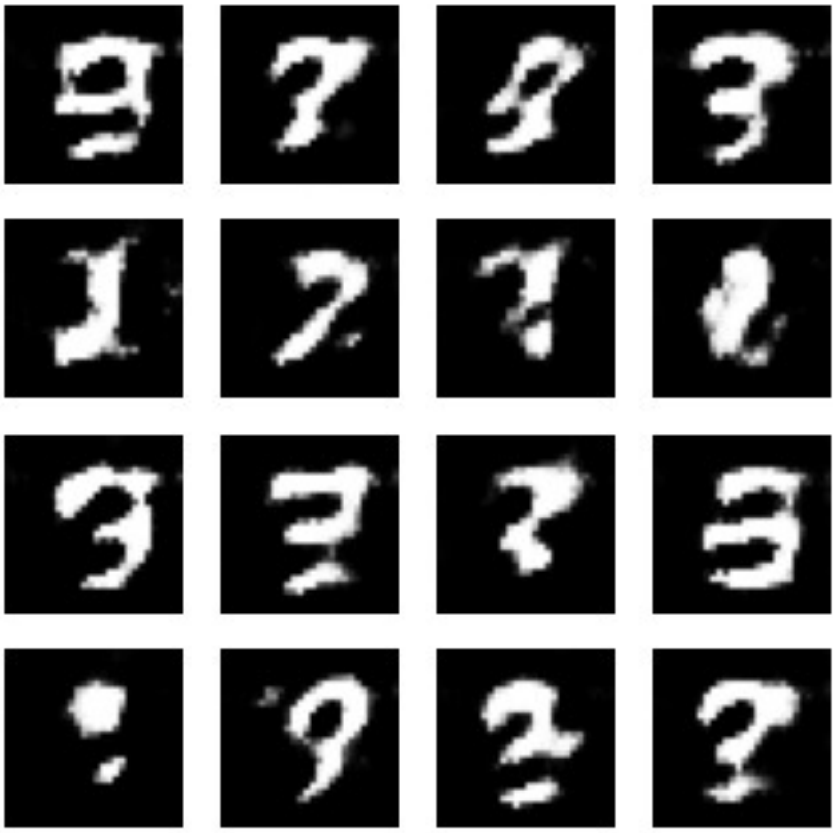
Comparing the images and the GIFs

```
for i in range(1,50,10):
  print(f'Epoch {i}')
  display(display_image(i))
  display(display_image_2(i))
  print('\n')

print('final images')
display(display_image(EPOCHS))
display(display_image_2(EPOCHS))
print('\n')

Epoch 1
```

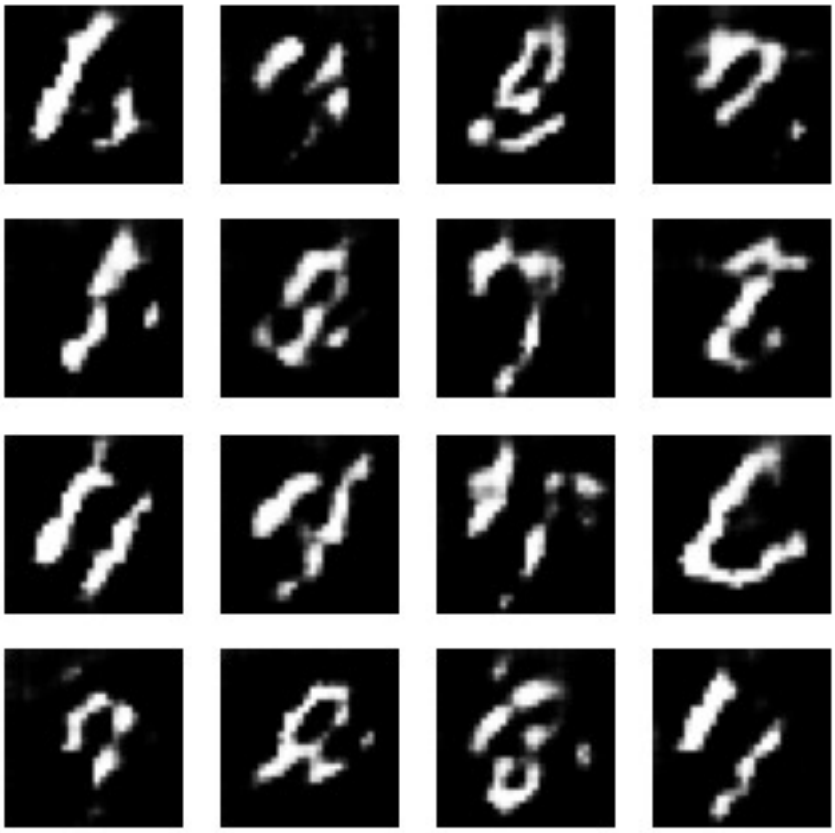




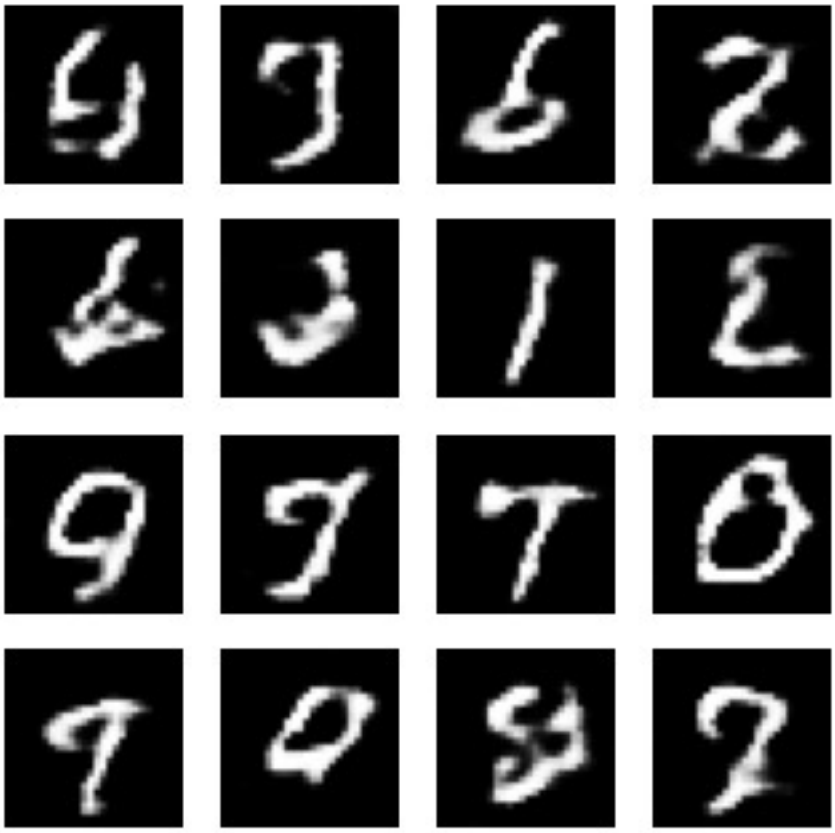
```
Epoch 11
```



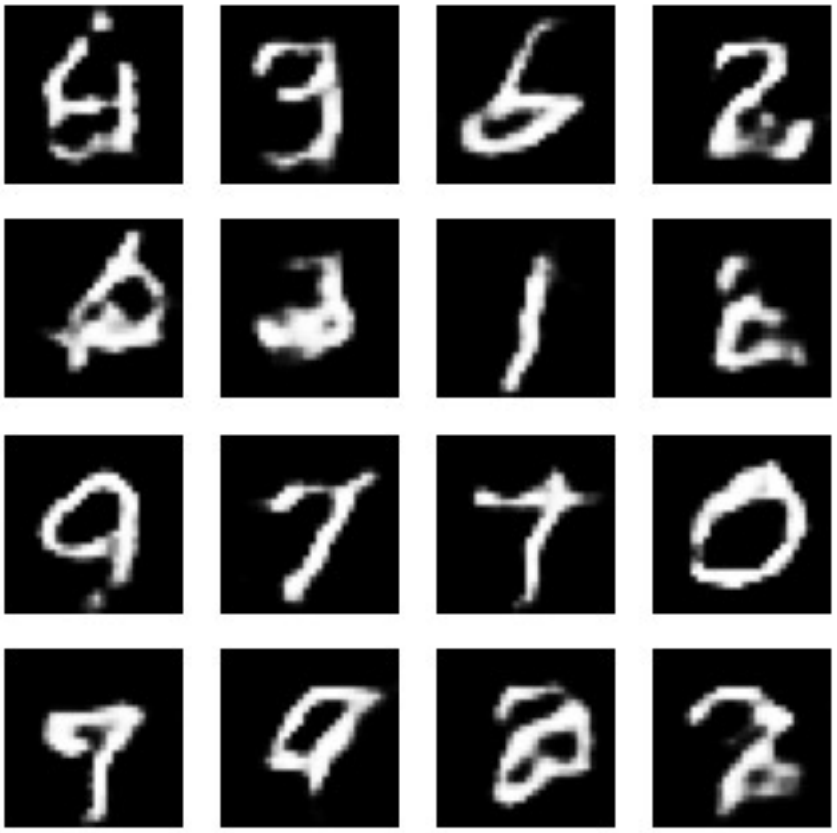
```
Epoch 21
```



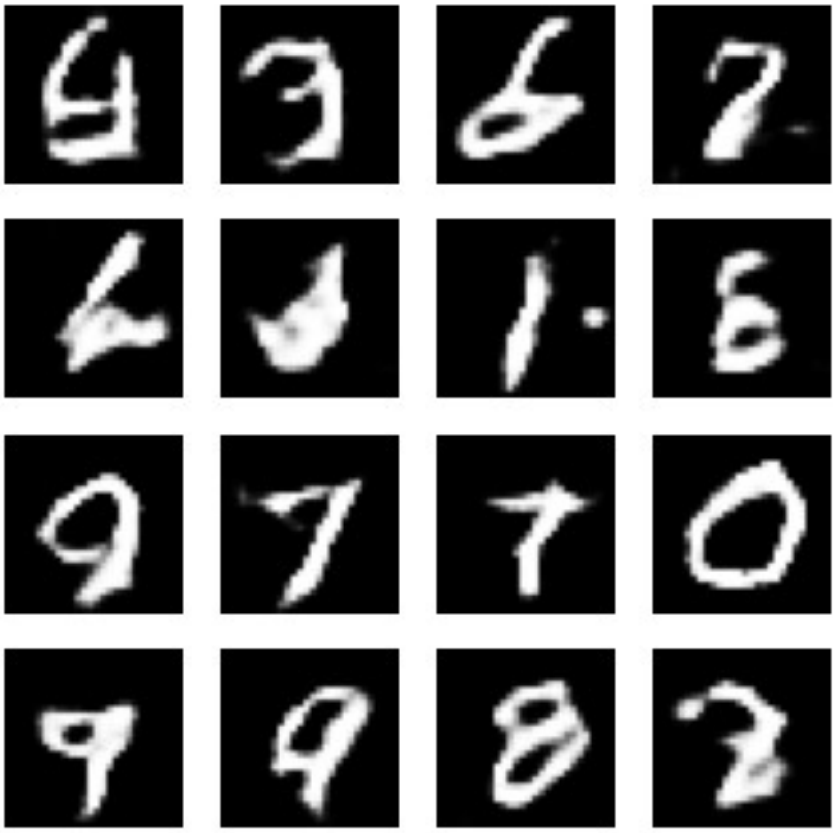
```
Epoch 31
```



```
Epoch 41
```



```
final images
```



The starting images are similar but the images get much better for the improved model. Same thing can be observed in the GIFs.