```
import tensorflow as tf
import numpy as np
import time
from matplotlib import pyplot as plt
from keras import layers, datasets, models
from IPython import display
import os

(X_train, y_train),(X_test, y_test) =
datasets.fashion_mnist.load_data()

train_data = np.concatenate((X_train, X_test), axis = 0)
train_labels = np.concatenate((y_train, y_test), axis = 0)

print(f"train_data.shape = {train_data.shape}")
print(f"X_train.shape = {X_train.shape}")
print(f"X_test.shape = {X_test.shape}")
```

```
train_data.shape = (70000, 28, 28)
X_train.shape = (60000, 28, 28)
X_test.shape = (10000, 28, 28)
```

```
train_data = ( train_data -127.50 ) / 127.50

train_data.min()
```

```
-1.0
```

```
train_data.max()
```

```
1.0
```

```
batch_size = 256
buffer_size = train_data.shape[0]

batched_train_data =
tf.data.Dataset.from_tensor_slices(train_data).shuffle(buffer_size).ba
tch(batch_size)

len(batched_train_data)
```

```
274
```

```
# We can get above value by

train_data.shape[0]/batch_size
```

```
273.4375
```

Generator

```
noise_dim = 100

def build_generator():
    model = models.Sequential(name='generator')

    model.add(layers.Dense(7 * 7 * 256, input_shape=(noise_dim,)))
    model.add(layers.BatchNormalization(momentum=0.8))
    model.add(layers.LeakyReLU())
    model.add(layers.Reshape((7, 7, 256)))

    model.add(layers.Conv2DTranspose(128, (5, 5), strides=(2, 2),
padding="same", kernel_initializer='he_uniform'))
    model.add(layers.BatchNormalization(momentum=0.8))
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2D(64, (5, 5), strides=(1, 1),
padding="same", kernel_initializer='he_uniform'))
    model.add(layers.BatchNormalization(momentum=0.8))
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(32, (3, 3), strides=(2, 2),
padding="same", kernel_initializer='he_uniform'))
    model.add(layers.BatchNormalization(momentum=0.8))
    model.add(layers.LeakyReLU())
    model.add(layers.Conv2DTranspose(1, (3, 3), padding="same",
strides=(1, 1), activation="tanh"))

    return model

generator = build_generator()
generator.summary()
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/layers/core/
dense.py:87: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an
`Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)
```

```
Model: "generator"
```

```
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┓
┃ Layer (type)                    ┃ Output Shape           ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━
┩
│ dense (Dense)                   │ (None, 12544)          │
```

```
1,266,944 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ batch_normalization             │ (None, 12544)              │
50,176 │
│ (BatchNormalization)            │                            │
       │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ leaky_re_lu (LeakyReLU)         │ (None, 12544)              │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ reshape (Reshape)               │ (None, 7, 7, 256)          │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d_transpose                │ (None, 14, 14, 128)        │
819,328 │
│ (Conv2DTranspose)               │                            │
       │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ batch_normalization_1           │ (None, 14, 14, 128)        │
512 │
│ (BatchNormalization)            │                            │
       │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ leaky_re_lu_1 (LeakyReLU)       │ (None, 14, 14, 128)        │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d (Conv2D)                 │ (None, 14, 14, 64)         │
204,864 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ batch_normalization_2           │ (None, 14, 14, 64)         │
256 │
│ (BatchNormalization)            │                            │
       │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ leaky_re_lu_2 (LeakyReLU)       │ (None, 14, 14, 64)         │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d_transpose_1              │ (None, 28, 28, 32)         │
18,464 │
```

```
| (Conv2DTranspose)                    |                           |
|
├──────────────────────────────────────┼───────────────────────────┼──────────
──────┤
| batch_normalization_3                | (None, 28, 28, 32)        |
128 |
| (BatchNormalization)                 |                           |
|
├──────────────────────────────────────┼───────────────────────────┼──────────
──────┤
| leaky_re_lu_3 (LeakyReLU)            | (None, 28, 28, 32)        |
0 |
├──────────────────────────────────────┼───────────────────────────┼──────────
──────┤
| conv2d_transpose_2                   | (None, 28, 28, 1)         |
289 |
| (Conv2DTranspose)                    |                           |
|
└──────────────────────────────────────┴───────────────────────────┴──────────
──────┘

 Total params: 2,360,961 (9.01 MB)

 Trainable params: 2,335,425 (8.91 MB)

 Non-trainable params: 25,536 (99.75 KB)
```

```
input_shape = (28,28,1)

def build_discriminator():
    model = models.Sequential(name='discriminator')

    model.add(layers.Conv2D(64, (3, 3), strides=(2, 2),
padding="same", kernel_initializer='he_uniform',
input_shape=input_shape))
    model.add(layers.BatchNormalization(momentum=0.7))
    model.add(layers.LeakyReLU(alpha=0.2))

    model.add(layers.Conv2D(128, (3, 3), strides=(2, 2),
padding="same", kernel_initializer='he_uniform'))
    model.add(layers.BatchNormalization(momentum=0.7))
    model.add(layers.LeakyReLU(alpha=0.2))

    model.add(layers.Conv2D(256, (3, 3), strides=(2, 2),
padding="same", kernel_initializer='he_uniform'))
    model.add(layers.BatchNormalization(momentum=0.7))
    model.add(layers.LeakyReLU(alpha=0.2))
    model.add(layers.MaxPool2D((2, 2)))

    model.add(layers.Flatten())
```

```
    model.add(layers.Dropout(0.3))
    model.add(layers.Dense(1, activation='sigmoid'))

    return model

discriminator = build_discriminator()
discriminator.summary()
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/layers/
convolutional/base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)
/opt/conda/lib/python3.10/site-packages/keras/src/layers/activations/
leaky_relu.py:41: UserWarning: Argument `alpha` is deprecated. Use
`negative_slope` instead.
  warnings.warn(

Model: "discriminator"
```

```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
│ conv2d_1 (Conv2D)                    │ (None, 14, 14, 64)          │
640 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ batch_normalization_4                │ (None, 14, 14, 64)          │
256 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ leaky_re_lu_4 (LeakyReLU)            │ (None, 14, 14, 64)          │
0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ conv2d_2 (Conv2D)                    │ (None, 7, 7, 128)           │
73,856 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ batch_normalization_5                │ (None, 7, 7, 128)           │
512 │
│ (BatchNormalization)                 │                             │
│
```

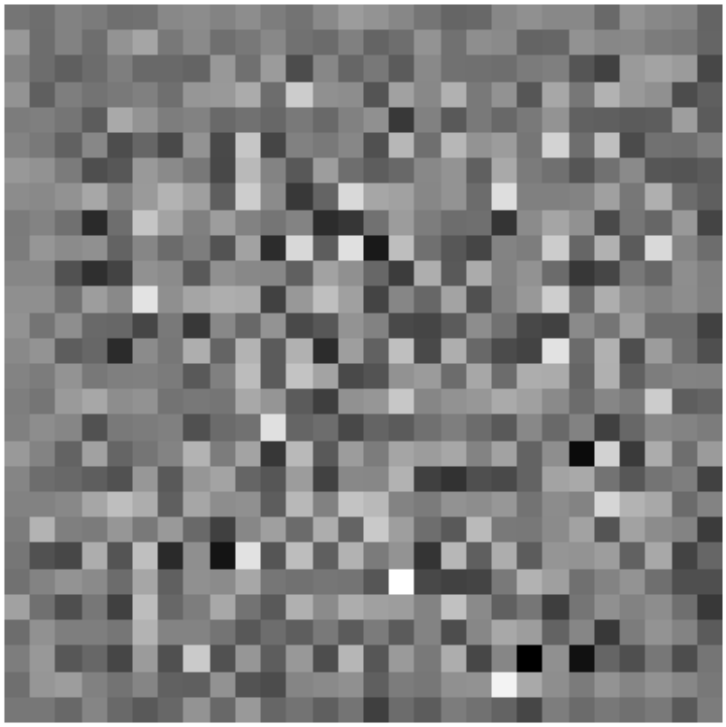
```
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ leaky_re_lu_5 (LeakyReLU)            │ (None, 7, 7, 128)           │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ conv2d_3 (Conv2D)                    │ (None, 4, 4, 256)           │
295,168 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ batch_normalization_6                │ (None, 4, 4, 256)           │
1,024 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ leaky_re_lu_6 (LeakyReLU)            │ (None, 4, 4, 256)           │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ max_pooling2d (MaxPooling2D)         │ (None, 2, 2, 256)           │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ flatten (Flatten)                    │ (None, 1024)                │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dropout (Dropout)                    │ (None, 1024)                │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dense_1 (Dense)                      │ (None, 1)                   │
1,025 │
└──────────────────────────────────────┴─────────────────────────────┴──────────
──────┘

 Total params: 372,481 (1.42 MB)

 Trainable params: 371,585 (1.42 MB)

 Non-trainable params: 896 (3.50 KB)
```

Testing

```
num_samples = 1
noises = tf.random.normal([num_samples, noise_dim])
gen_img = generator(noises, training = False)
plt.imshow(gen_img[0,:,:,0], cmap = 'gray')
plt.axis('off')
```

```
print(discriminator(gen_img))
plt.show()
```

```
tf.Tensor([[0.50262094]], shape=(1, 1), dtype=float32)
```



Optimizer

```
generator_optimizer = tf.keras.optimizers.Adam(learning_rate = 0.0001,
beta_1 = 0.5)
discriminator_optimizer = tf.keras.optimizers.Adam(learning_rate =
0.0001, beta_1 = 0.5)
```

Loss Function

```
def generator_loss(fake_output):
    return -tf.reduce_mean(fake_output)

def discriminator_loss(real_output, fake_output):
    real_loss = tf.reduce_mean(tf.nn.relu(1.0 - real_output))
    fake_loss = tf.reduce_mean(tf.nn.relu(1.0 + fake_output))
    return real_loss + fake_loss
```

Training

```
noise_dim = noise_dim
batch_size = batch_size
```

```
print(f"batch_size = {batch_size}")
print(f"noise_dim = {noise_dim}")

batch_size = 256
noise_dim = 100

@tf.function


def train_step (real_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)

    fake_outputs = discriminator(generated_images, training  = True)

    real_outputs = discriminator(real_images, training = True)

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

  generator_gradients = gen_tape.gradient(gen_loss,
generator.trainable_variables)
  discriminator_gradients = disc_tape.gradient(disc_loss,
discriminator.trainable_variables)

  generator_optimizer.apply_gradients(zip(generator_gradients,
generator.trainable_variables))
  discriminator_optimizer.apply_gradients(zip(discriminator_gradients,
discriminator.trainable_variables))

  return disc_loss, gen_loss


# Test generator on following noises throughout training
num_samples = 16
test_noises = tf.random.normal([num_samples,noise_dim])

def generate_and_save_image(model, epoch, test_input):
    rows = 4
    cols = 4

    plt.figure(figsize=(rows*2, cols*2))
    plt.suptitle(f"Epoch = {epoch}")

    generated_images = model(test_input)
```

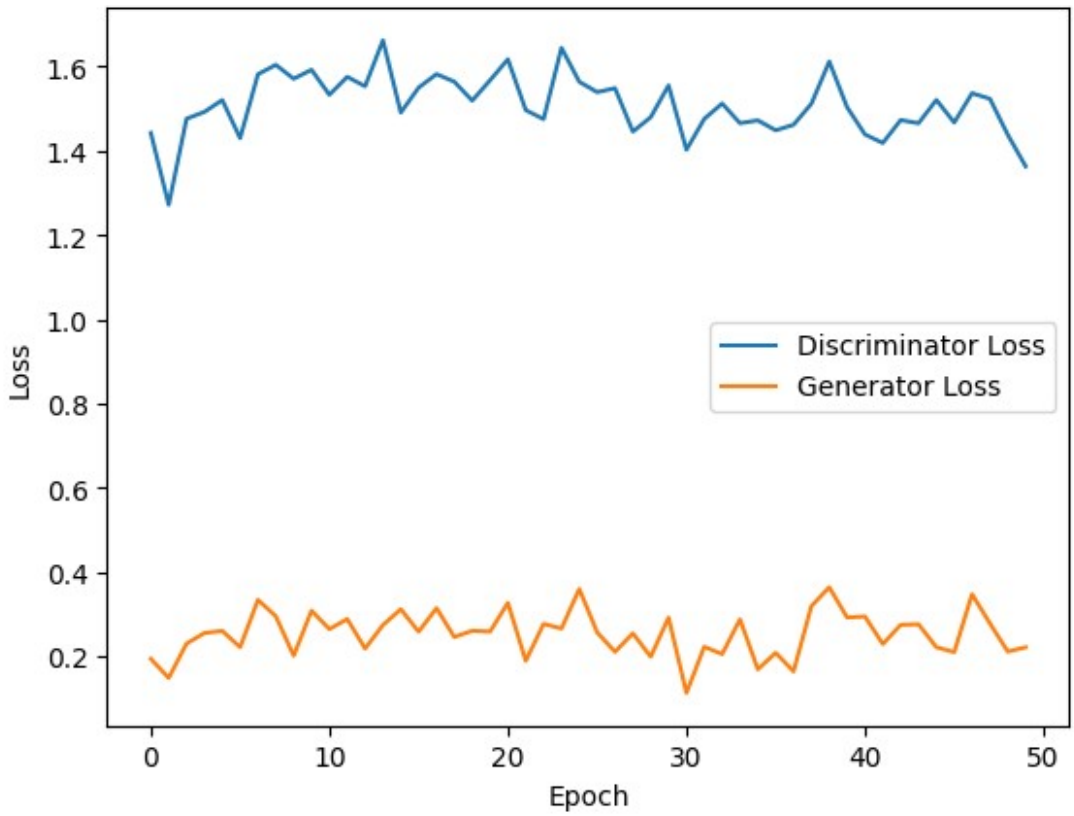
```
    for i in range(rows * cols):
        ax = plt.subplot(rows, cols, i + 1)
        ax.axis('off')
        ax.imshow(generated_images[i, :, :, 0] * 127.5 + 127.5,
cmap='gray')

    plt.tight_layout()

    if not os.path.exists("images"):
        os.makedirs("images")

    plt.savefig(f"images/image-at-epoch-{epoch:04d}.png")
    plt.show()

# Define checkpoint directory and checkpoint prefix
checkpoint_dir = './training_checkpoints'
checkpoint_prefix = os.path.join(checkpoint_dir, "ckpt")

# Create a checkpoint object
checkpoint = tf.train.Checkpoint(generator_optimizer =
generator_optimizer,
                                 discriminator_optimizer =
discriminator_optimizer,
                                 generator = generator,
                                 discriminator = discriminator)


# Restore the latest checkpoint if available
latest_checkpoint = tf.train.latest_checkpoint(checkpoint_dir)
if latest_checkpoint:
    checkpoint.restore(latest_checkpoint)
    print("Checkpoint restored:", latest_checkpoint)

def train(dataset, epochs):
    disc_losses = []
    gen_losses = []

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

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

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

        display.clear_output(wait=True)
        print(f"Epoch = {epoch}, disc_loss = {disc_loss}, gen_loss =
{gen_loss}, time_taken = {time.time() - start} seconds")
        generate_and_save_image(model=generator, epoch=epoch,
```

```
test_input=test_noises)

        if epoch % 5 == 0:
            checkpoint.save(file_prefix=checkpoint_prefix)
            print(f"checkpoint saved for epoch = {epoch}")

        history = {
            'discriminator_losses': disc_losses,
            'generator_losses': gen_losses
        }

        print(f"history of epoch = {epoch} saved")

        print(f"epoch = {epoch+1} started")

    return history

epochs = 50
history = train(batched_train_data, epochs = epochs)
```

```
Epoch = 50, disc_loss = 1.3630861043930054, gen_loss = -
0.2210840880870819, time_taken = 14.722540855407715 seconds
```


```
checkpoint saved for epoch = 50
history of epoch = 50 saved
epoch = 51 started

import pickle

# Ensure the output directory exists
output_dir = '/kaggle/working/'
os.makedirs(output_dir, exist_ok=True)

# Save the history object to the output directory
output_path = os.path.join(output_dir, 'dcgan-fashion-mnist-hingeloss-
```

```
history-before-modification.pkl')
with open(output_path, 'wb') as pickle_file:
    pickle.dump(history, pickle_file)

# Load the history from the pickle file
with open('dcgan-fashion-mnist-hingeloss-history-before-
modification.pkl', 'rb') as pickle_file:
    loaded_history_pickle = pickle.load(pickle_file)

# Access the loaded history
discriminator_losses = loaded_history_pickle['discriminator_losses']
generator_losses = loaded_history_pickle['generator_losses']

neg_gen_losses  = []
for i in generator_losses:
    neg_gen_losses.append(-1*i)

plt.plot(discriminator_losses, label='Discriminator Loss')
plt.plot(neg_gen_losses, label='Generator Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```



```
generator.save("generator-dcgan-fashion-mnist-hingeloss-before-modification.h5")

import shutil

# Define the directory containing the images and the output zip file
images_dir = '/kaggle/working/images'
output_zip = '/kaggle/working/images-fashion-mnist-hingeloss-before-modification.zip'

# Zip the directory
shutil.make_archive(output_zip.replace('.zip', ''), 'zip', images_dir)

print(f"Zipped {images_dir} to {output_zip}")
```

```
Zipped /kaggle/working/images to /kaggle/working/images-fashion-mnist-hingeloss-before-modification.zip
```