21BDS0340 - Abhinav Dinesh Srivatsa

In [1]:
```
import tensorflow as tf
from tensorflow.keras import layers
import matplotlib.pyplot as plt
import time
from IPython.display import clear_output
```

In [2]:
```
BATCH_SIZE = 256
(X, y), (_, _) = tf.keras.datasets.mnist.load_data()
X = X.reshape(X.shape[0], 28, 28, 1)
X = (X - 127.5) / 127.5
X = tf.data.Dataset.from_tensor_slices(X).shuffle(len(X)).batch(BATCH_SIZ
X
```

```
2024-10-08 18:18:34.867058: I metal_plugin/src/device/metal_device.cc:115
4] Metal device set to: Apple M1 Pro
2024-10-08 18:18:34.867084: I metal_plugin/src/device/metal_device.cc:296]
systemMemory: 16.00 GB
2024-10-08 18:18:34.867091: I metal_plugin/src/device/metal_device.cc:313]
maxCacheSize: 5.33 GB
2024-10-08 18:18:34.867558: I tensorflow/core/common_runtime/pluggable_dev
ice/pluggable_device_factory.cc:303] Could not identify NUMA node of platf
orm GPU ID 0, defaulting to 0. Your kernel may not have been built with NU
MA support.
2024-10-08 18:18:34.868004: I tensorflow/core/common_runtime/pluggable_dev
ice/pluggable_device_factory.cc:269] Created TensorFlow device (/job:local
host/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical Pluggable
Device (device: 0, name: METAL, pci bus id: <undefined>)
```

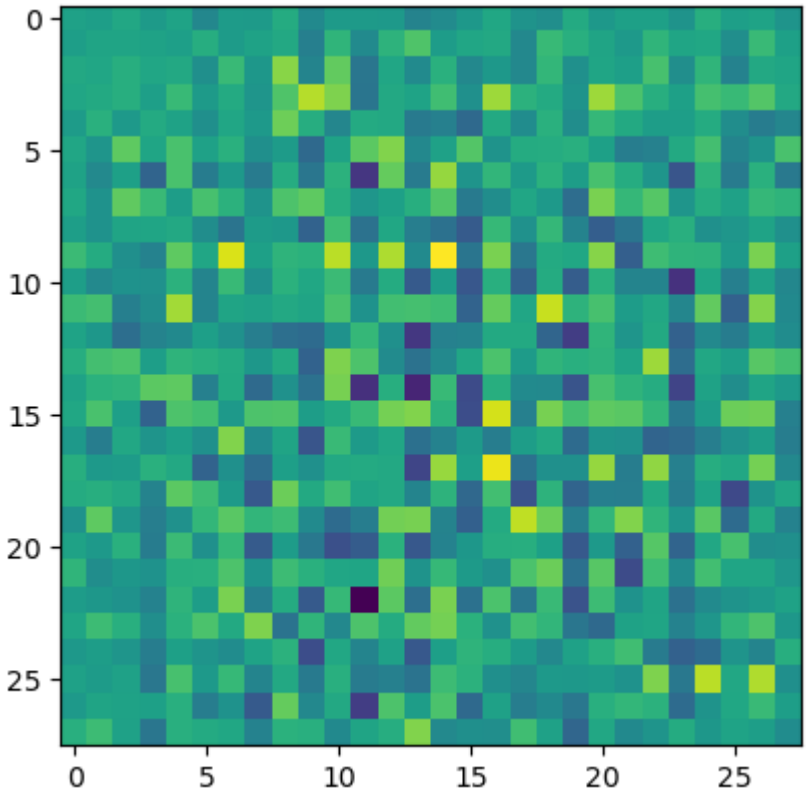
Out[2]:
```
<_BatchDataset element_spec=TensorSpec(shape=(None, 28, 28, 1), dtype=t
f.float64, name=None)>
```

In [3]:
```
generator = tf.keras.Sequential([
    layers.Input((100, )),
    layers.Dense(7 * 7 * 256, use_bias=False),
    layers.BatchNormalization(),
    layers.LeakyReLU(),

    layers.Reshape((7, 7, 256)),
    layers.Conv2DTranspose(128, (5, 5), strides=(1, 1), padding='same', u
    layers.BatchNormalization(),
    layers.LeakyReLU(),

    layers.Conv2DTranspose(64, (5, 5), strides=(2, 2), padding='same', us
    layers.BatchNormalization(),
    layers.LeakyReLU(),

    layers.Conv2DTranspose(1, (5, 5), strides=(2, 2), padding='same', use
])

generator.summary()
```

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

 batch_normalization (Batch  (None, 12544)             50176
 Normalization)

 leaky_re_lu (LeakyReLU)     (None, 12544)             0

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

 conv2d_transpose (Conv2DTr  (None, 7, 7, 128)         819200
 anspose)

 batch_normalization_1 (Bat  (None, 7, 7, 128)         512
 chNormalization)

 leaky_re_lu_1 (LeakyReLU)   (None, 7, 7, 128)         0

 conv2d_transpose_1 (Conv2D  (None, 14, 14, 64)        204800
 Transpose)

 batch_normalization_2 (Bat  (None, 14, 14, 64)        256
 chNormalization)

 leaky_re_lu_2 (LeakyReLU)   (None, 14, 14, 64)        0

 conv2d_transpose_2 (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)
_________________________________________________________________
```

In [4]:
```
noise = tf.random.normal([1, 100])
generated_image = generator(noise, training=False)
plt.imshow(generated_image[0, :, :, 0])
```

Out[4]:
```
<matplotlib.image.AxesImage at 0x15dc95b20>
```



In [5]:
```
discriminator = tf.keras.Sequential([
    layers.Input((28, 28, 1)),
    layers.Conv2D(64, (5, 5), strides=(2, 2), padding='same'),
    layers.LeakyReLU(),
    layers.Dropout(0.3),

    layers.Conv2D(128, (5, 5), strides=(2, 2), padding='same'),
    layers.LeakyReLU(),
    layers.Dropout(0.3),

    layers.Flatten(),
    layers.Dense(1)
])

discriminator.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 14, 14, 64)        1664

 leaky_re_lu_3 (LeakyReLU)   (None, 14, 14, 64)        0

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

 conv2d_1 (Conv2D)           (None, 7, 7, 128)         204928

 leaky_re_lu_4 (LeakyReLU)   (None, 7, 7, 128)         0

 dropout_1 (Dropout)         (None, 7, 7, 128)         0

 flatten (Flatten)           (None, 6272)              0

 dense_1 (Dense)             (None, 1)                 6273

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

In [6]:
```
decision = discriminator(generated_image)
decision
```

Out[6]:
```
<tf.Tensor: shape=(1, 1), dtype=float32, numpy=array([[8.467713e-05]], d
type=float32)>
```

In [7]:
```
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.ones_like(fake_output), fake_output)
    return real_loss + fake_loss

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

In [8]:
```
EXAMPLES = 16
NOISE_DIM = 100
EPOCHS = 50

gen_optimizer = tf.keras.optimizers.Adam(1e-4)
disc_optimizer = tf.keras.optimizers.Adam(1e-4)
seed = tf.random.normal([EXAMPLES, NOISE_DIM])

@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)
```

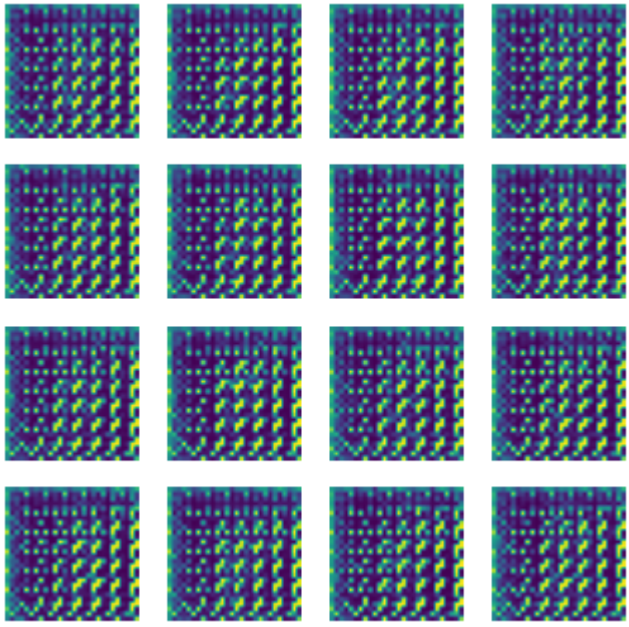
```
        gen_loss = generator_loss(fake_output)
        disc_loss = discriminator_loss(real_output, fake_output)

        generator_gradients = gen_tape.gradient(gen_loss, generator.train
        discriminator_gradients = disc_tape.gradient(disc_loss, discrimin

        gen_optimizer.apply_gradients(zip(generator_gradients, generator.
        disc_optimizer.apply_gradients(zip(discriminator_gradients, discr
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.Adam`
runs slowly on M1/M2 Macs, please use the legacy Keras optimizer instead,
located at `tf.keras.optimizers.legacy.Adam`.
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.Adam`
runs slowly on M1/M2 Macs, please use the legacy Keras optimizer instead,
located at `tf.keras.optimizers.legacy.Adam`.
```

In [9]:
```
def generate_and_save_images(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)
        plt.axis('off')

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

In [10]:
```
def train(dataset, epochs):
    for epoch in range(epochs):
        start = time.time()

        for image_batch in dataset:
            train_step(image_batch)

        clear_output(wait=True)
        generate_and_save_images(generator, epoch + 1, seed)

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

    clear_output(wait=True)
    generate_and_save_images(generator, epochs, seed)
```

In [11]:
```
%%time
train(X, EPOCHS)
```



```
CPU times: user 3min 27s, sys: 2min 16s, total: 5min 43s
Wall time: 16min 53s
```

In [12]:
```
noise = tf.random.normal([1, 100])
generated_image = generator(noise, training=False)
plt.imshow(generated_image[0, :, :, 0])
```

Out[12]:
```
<matplotlib.image.AxesImage at 0x350bc1fa0>
```