10: GAN FOR HANDWRITTEN DIGITS

AIM:

To build and train a GAN that generates realistic handwritten digits from the MNIST dataset.

PROCEDURE:

1. Load and preprocess the MNIST dataset.
2. Define generator and discriminator.
3. Compile models and set up loss functions.
4. Train for multiple epochs.
5. Generate and visualize fake digits.

CODE:

```
import tensorflow as tf
from tensorflow.keras import layers
import numpy as np
import matplotlib.pyplot as plt

# Load and preprocess the data
(train_images, _), (_, _) = tf.keras.datasets.mnist.load_data()
train_images = train_images.reshape(-1, 28, 28, 1).astype("float32")
train_images = (train_images - 127.5) / 127.5  # Normalize to [-1, 1]

BUFFER_SIZE = 60000
BATCH_SIZE = 128

# Ensure batch size is fixed to prevent shape mismatch errors
train_dataset = tf.data.Dataset.from_tensor_slices(train_images) \
```

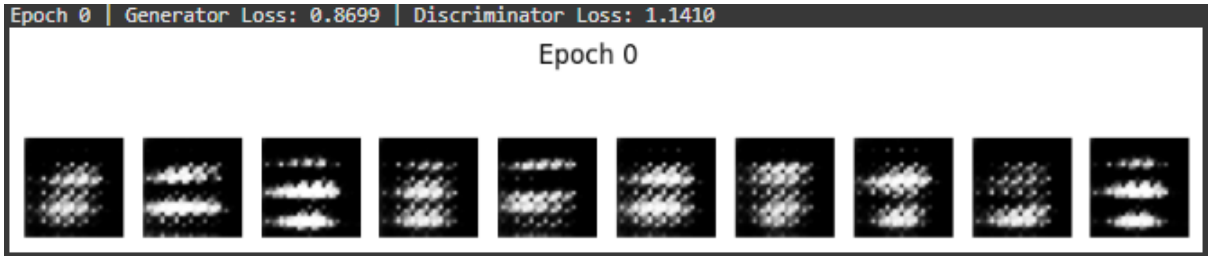
```
    .shuffle(BUFFER_SIZE) \
    .batch(BATCH_SIZE, drop_remainder=True)


# Generator Model
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)))

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

    model.add(layers.Conv2DTranspose(64, (5, 5), strides=(2, 2), 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'))

    return model

# Discriminator Model
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

# Loss and optimizers
cross_entropy = tf.keras.losses.BinaryCrossentropy(from_logits=True)

generator = make_generator_model()
discriminator = make_discriminator_model()

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

# Training step
@tf.function
def train_step(images):
    noise = tf.random.normal([BATCH_SIZE, 100])

    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 = cross_entropy(tf.ones_like(fake_output), fake_output)
        disc_loss = cross_entropy(tf.ones_like(real_output), real_output) + \
                    cross_entropy(tf.zeros_like(fake_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

# Generate and plot images
def generate_and_plot_images(model, epoch, test_input):
    predictions = model(test_input, training=False)
    fig = plt.figure(figsize=(10, 2))
    for i in range(predictions.shape[0]):
        plt.subplot(1, predictions.shape[0], i+1)
        plt.imshow((predictions[i, :, :, 0] + 1) / 2.0, cmap='gray')
        plt.axis('off')
    plt.suptitle(f"Epoch {epoch}")
    plt.show()
```

```
# Train function
def train(dataset, epochs):
    seed = tf.random.normal([10, 100])
    for epoch in range(epochs):
        for image_batch in dataset:
            g_loss, d_loss = train_step(image_batch)
        if epoch % 5 == 0:
            print(f"Epoch {epoch} | Generator Loss: {g_loss:.4f} | Discriminator Loss: {d_loss:.4f}")
            generate_and_plot_images(generator, epoch, seed)

# Run training
train(train_dataset, epochs=30)
```

OUTPUT:



RESULT:

GAN successfully generated realistic handwritten digits after training on MNIST dataset.