Ex:- 12 Implement a Deep Convolutional GAN to generate complex color images

Aim:- To implement a Deep Convolution Generative Adversarial Network (DCGAN) that can learn to generate realistic color images from random noise using the CIFAR-10 dataset

Objectives:-

1. To understand and apply the Generative Adversarial Network (GAN) framework.
2. To design and train a deep convolutional Generator that creates synthetic color images
3. To desin and train a convolutional Discriminator that distinguishes blw real and fake images
4. To evalute the visual quality of generated images as training progresses.

Pseudocode :-

1. Import required libraries
2. Load CIFAR-10 dataset and normalize image pixel b/w [-1, 1]
3. Define the generator network
4. Define the Discriminator network.
5. Combine both networks
6. training loop.
7. Save trained generator model and generated samples

Result :-

A deep convolutional GAN was successfully implemented to generate realistic color images. After sufficient epochs (≈50+) the generator produces images that visually resemble real CIFAR-10 samples, demonstrating the power of DCGANs in unsupervised image generation.

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output:-

During training

- the generator loss decreases gradually - meaning its improving at producing realistic images
- The Discriminator loss fluctuates - indicating the adversarial balance b/w the two networks.
- generated images start as random noise and progressively resemble CIFAR-10 like objects.

The CNN model to ~~classify CIFAR~~ training

Epoch over Training & validation.

Epoch 1/50 Generator loss :- 0.9890
Discriminator loss :- 1.3835

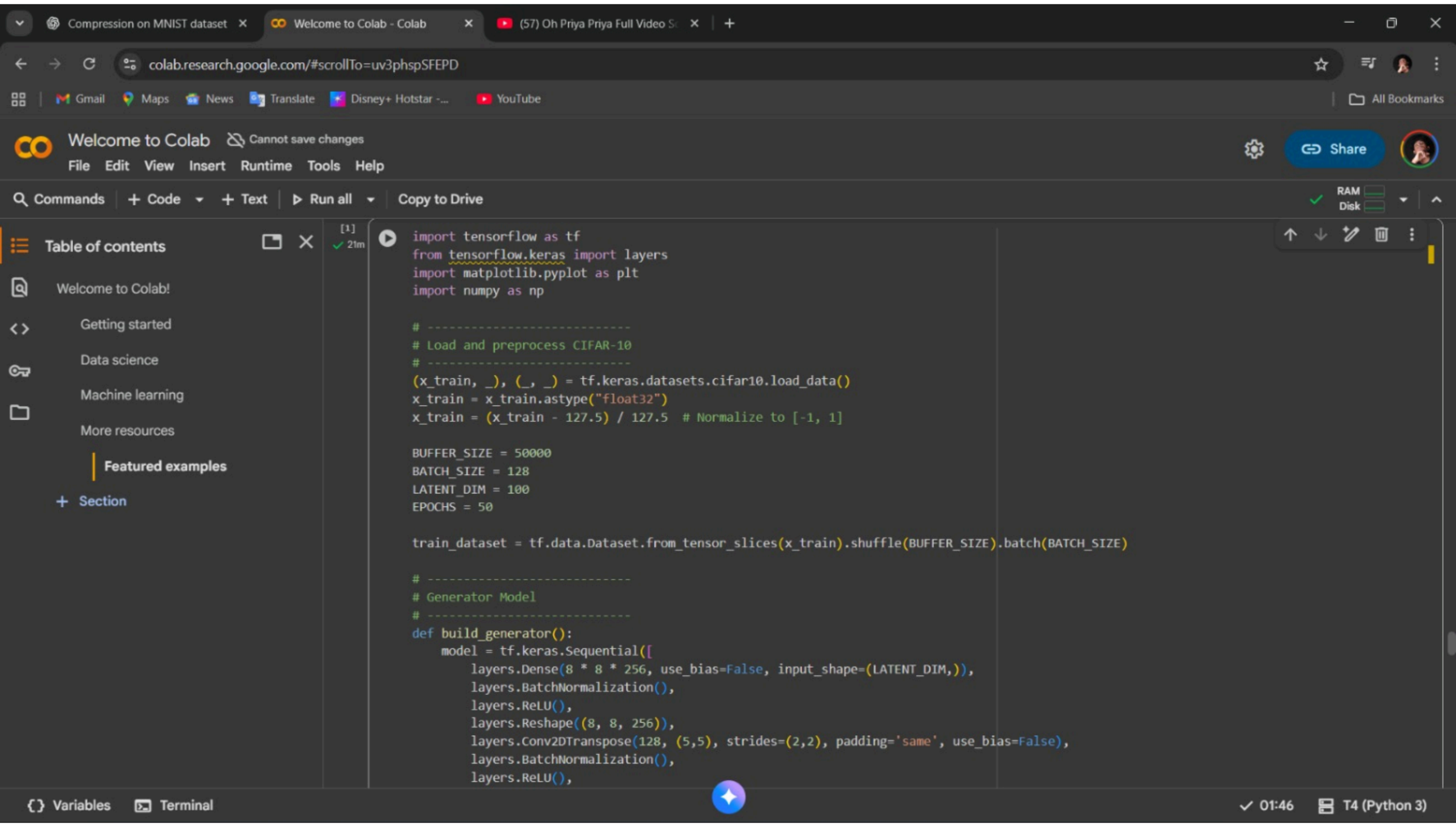
10/50 Generator loss :- 2.3227
Discriminator loss :- 0.9163

20/50 Generator loss :- 2.1335
Discriminator loss :- 0.8985

30/50 Generator loss :- 1.3841
Discriminator loss :- 1.0203

40/50 Generator loss :- 1.4775
Discriminator loss :- 0.9890

50/50 Generator loss :- 1.1928
Discriminator loss :- 1.1307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import tensorflow as tf
from tensorflow.keras import layers
import matplotlib.pyplot as plt
import numpy as np
# ----------------------------
# Load and preprocess CIFAR-10
# ----------------------------
(x_train, _), (_, _) = tf.keras.datasets.cifar10.load_data()
x_train = x_train.astype("float32")
x_train = (x_train - 127.5) / 127.5 # Normalize to [-1, 1]
BUFFER_SIZE = 50000
BATCH_SIZE = 128
LATENT_DIM = 100
EPOCHS = 50
train_dataset = tf.data.Dataset.from_tensor_slices(x_train).shuffle(BUFFER_SIZE).batch(BATCH_SIZE)
# ----------------------------
# Generator Model
# ----------------------------
def build_generator():
    model = tf.keras.Sequential([
        layers.Dense(8 * 8 * 256, use_bias=False, input_shape=(LATENT_DIM,)),
        layers.BatchNormalization(),
        layers.ReLU(),
        layers.Reshape((8, 8, 256)),
        layers.Conv2DTranspose(128, (5,5), strides=(2,2), padding='same', use_bias=False),
        layers.BatchNormalization(),
        layers.ReLU(),
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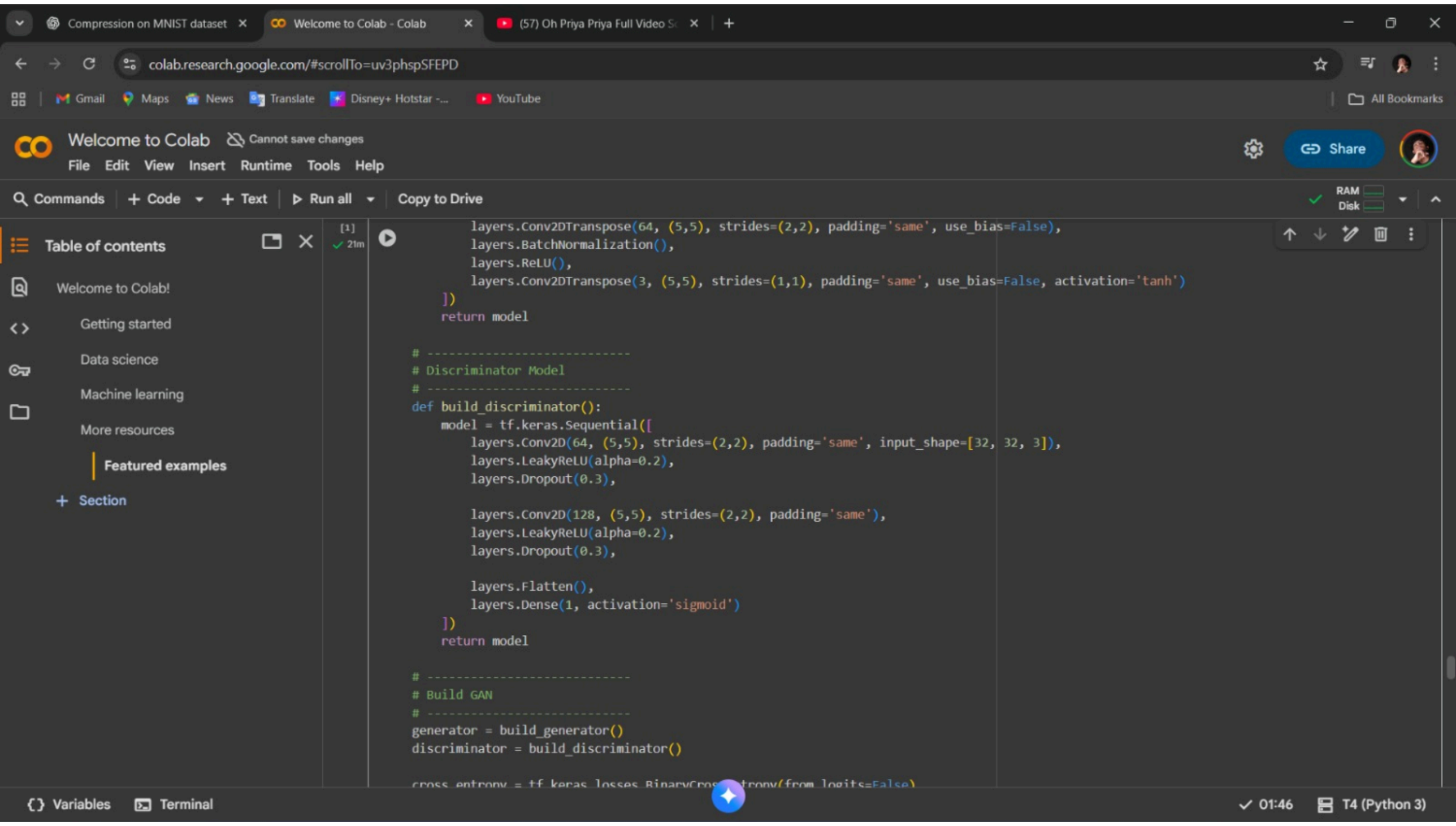
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layers.Conv2DTranspose(64, (5,5), strides=(2,2), padding='same', use_bias=False),
layers.BatchNormalization(),
layers.ReLU(),
layers.Conv2DTranspose(3, (5,5), strides=(1,1), padding='same', use_bias=False, activation='tanh')
])
return model
# ----------------------------
# Discriminator Model
# ----------------------------
def build_discriminator():
model = tf.keras.Sequential([
layers.Conv2D(64, (5,5), strides=(2,2), padding='same', input_shape=[32, 32, 3]),
layers.LeakyReLU(alpha=0.2),
layers.Dropout(0.3),
layers.Conv2D(128, (5,5), strides=(2,2), padding='same'),
layers.LeakyReLU(alpha=0.2),
layers.Dropout(0.3),
layers.Flatten(),
layers.Dense(1, activation='sigmoid')
])
return model
# ----------------------------
# Build GAN
# ----------------------------
generator = build_generator()
discriminator = build_discriminator()
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```
# ----------------------------
# Training functions
# ----------------------------
@tf.function
def train_step(images):
    noise = tf.random.normal([BATCH_SIZE, LATENT_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 = cross_entropy(tf.ones_like(fake_output), fake_output)
        disc_loss_real = cross_entropy(tf.ones_like(real_output), real_output)
        disc_loss_fake = cross_entropy(tf.zeros_like(fake_output), fake_output)
        disc_loss = disc_loss_real + disc_loss_fake

    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 display images
# ----------------------------
def generate_and_save_images(model, epoch):
    noise = tf.random.normal([16, LATENT_DIM])
```

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```
# ----------------------------
# Train the DCGAN
# ----------------------------
for epoch in range(1, EPOCHS + 1):
    for image_batch in train_dataset:
        g_loss, d_loss = train_step(image_batch)

    print(f"Epoch {epoch}/{EPOCHS} | Generator Loss: {g_loss:.4f} | Discriminator Loss: {d_loss:.4f}")
    if epoch % 10 == 0:
        generate_and_save_images(generator, epoch)
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 ━━━━━━━━━━━━━━━━━━━━ 14s 0us/step
/usr/local/lib/python3.12/dist-packages/keras/src/layers/core/dense.py:93: UserWarning: Do not pass an `input_shape`/`input_dim` argument to
  super().__init__(activity_regularizer, **kwargs)
/usr/local/lib/python3.12/dist-packages/keras/src/layers/convolutional/base_conv.py:113: UserWarning: Do not pass an `input_shape`/`input_d
  super().__init__(activity_regularizer, **kwargs)
/usr/local/lib/python3.12/dist-packages/keras/src/layers/activations/leaky_relu.py:41: UserWarning: Argument `alpha` is deprecated. Use `neg
  warnings.warn(
Epoch 1/50 | Generator Loss: 0.9840 | Discriminator Loss: 1.3835
Epoch 2/50 | Generator Loss: 3.1005 | Discriminator Loss: 0.7256
Epoch 3/50 | Generator Loss: 2.4980 | Discriminator Loss: 0.3565
Epoch 4/50 | Generator Loss: 2.6720 | Discriminator Loss: 0.3086
Epoch 5/50 | Generator Loss: 2.6250 | Discriminator Loss: 0.2491
Epoch 6/50 | Generator Loss: 2.4617 | Discriminator Loss: 0.7983
Epoch 7/50 | Generator Loss: 2.7962 | Discriminator Loss: 0.2988
Epoch 8/50 | Generator Loss: 5.6742 | Discriminator Loss: 0.2018
Epoch 9/50 | Generator Loss: 3.3226 | Discriminator Loss: 0.4563
Epoch 10/50 | Generator Loss: 2.3227 | Discriminator Loss: 0.9163
```

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Epoch 10

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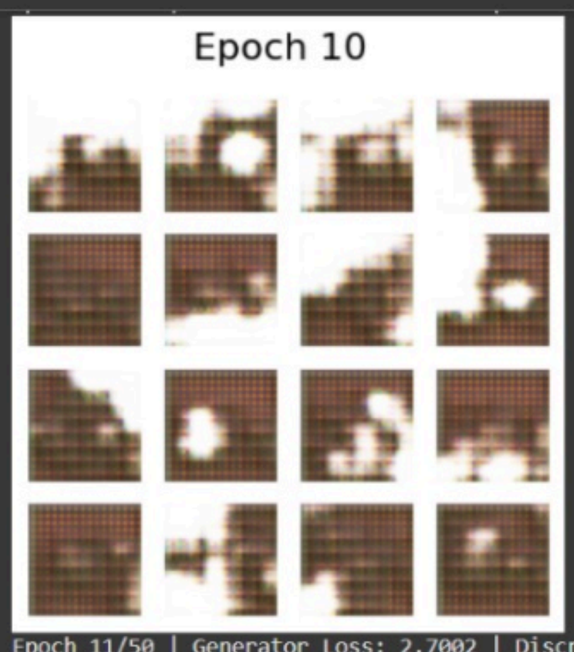
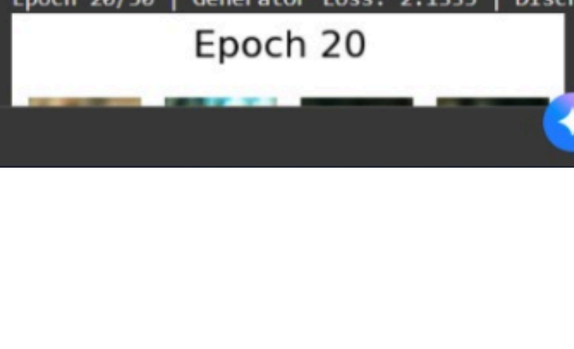



```
Epoch 11/50 | Generator Loss: 2.7002 | Discriminator Loss: 0.5032
Epoch 12/50 | Generator Loss: 2.1884 | Discriminator Loss: 0.5766
Epoch 13/50 | Generator Loss: 1.7097 | Discriminator Loss: 1.3700
Epoch 14/50 | Generator Loss: 1.7213 | Discriminator Loss: 0.6607
Epoch 15/50 | Generator Loss: 1.5948 | Discriminator Loss: 0.7198
Epoch 16/50 | Generator Loss: 1.8186 | Discriminator Loss: 0.8346
Epoch 17/50 | Generator Loss: 1.6664 | Discriminator Loss: 0.8812
Epoch 18/50 | Generator Loss: 1.3570 | Discriminator Loss: 1.1007
Epoch 19/50 | Generator Loss: 2.0084 | Discriminator Loss: 0.4675
Epoch 20/50 | Generator Loss: 2.1335 | Discriminator Loss: 0.8985
```



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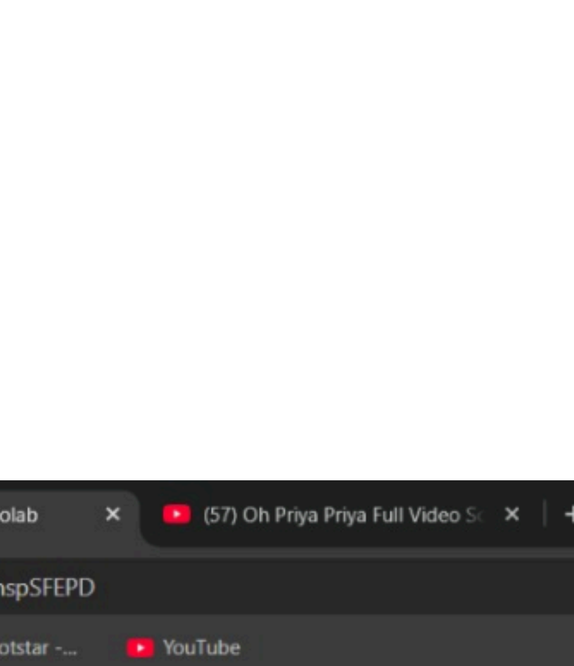
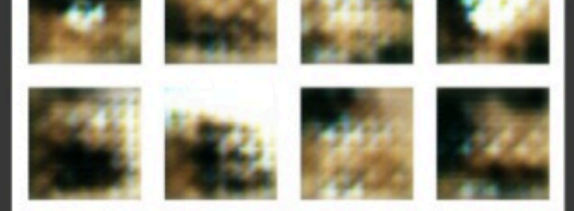



```
Epoch 21/50 | Generator Loss: 1.8843 | Discriminator Loss: 0.8181
Epoch 22/50 | Generator Loss: 1.8564 | Discriminator Loss: 1.4031
Epoch 23/50 | Generator Loss: 1.5022 | Discriminator Loss: 0.8977
Epoch 24/50 | Generator Loss: 2.4385 | Discriminator Loss: 0.5607
Epoch 25/50 | Generator Loss: 1.5738 | Discriminator Loss: 0.7621
Epoch 26/50 | Generator Loss: 1.3153 | Discriminator Loss: 1.1137
Epoch 27/50 | Generator Loss: 1.9380 | Discriminator Loss: 0.6921
Epoch 28/50 | Generator Loss: 1.0993 | Discriminator Loss: 1.0375
Epoch 29/50 | Generator Loss: 1.1910 | Discriminator Loss: 1.2646
Epoch 30/50 | Generator Loss: 1.3841 | Discriminator Loss: 1.0203
```



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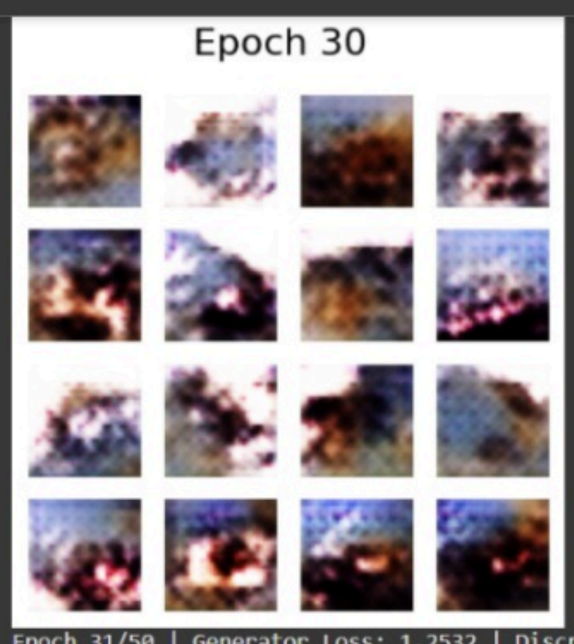
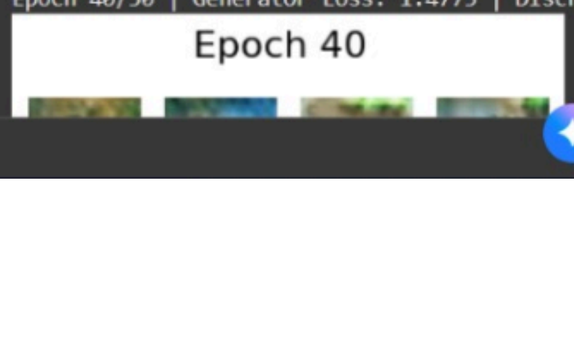



```
Epoch 31/50 | Generator Loss: 1.2532 | Discriminator Loss: 1.0982
Epoch 32/50 | Generator Loss: 1.3170 | Discriminator Loss: 1.7191
Epoch 33/50 | Generator Loss: 1.2660 | Discriminator Loss: 1.3758
Epoch 34/50 | Generator Loss: 1.3181 | Discriminator Loss: 0.9501
Epoch 35/50 | Generator Loss: 1.3896 | Discriminator Loss: 1.0550
Epoch 36/50 | Generator Loss: 1.0913 | Discriminator Loss: 1.2456
Epoch 37/50 | Generator Loss: 1.1644 | Discriminator Loss: 1.3073
Epoch 38/50 | Generator Loss: 1.1355 | Discriminator Loss: 1.1686
Epoch 39/50 | Generator Loss: 1.1943 | Discriminator Loss: 1.2741
Epoch 40/50 | Generator Loss: 1.4775 | Discriminator Loss: 0.9890
```



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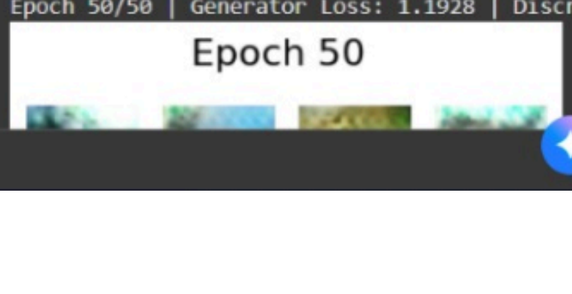
```
Epoch 41/50 | Generator Loss: 1.0110 | Discriminator Loss: 1.6527
Epoch 42/50 | Generator Loss: 1.3656 | Discriminator Loss: 1.1725
Epoch 43/50 | Generator Loss: 1.2712 | Discriminator Loss: 1.0234
Epoch 44/50 | Generator Loss: 1.1048 | Discriminator Loss: 1.0794
Epoch 45/50 | Generator Loss: 0.9776 | Discriminator Loss: 1.3757
Epoch 46/50 | Generator Loss: 1.1483 | Discriminator Loss: 1.4964
Epoch 47/50 | Generator Loss: 0.9877 | Discriminator Loss: 1.1750
Epoch 48/50 | Generator Loss: 1.1319 | Discriminator Loss: 1.0681
Epoch 49/50 | Generator Loss: 1.0524 | Discriminator Loss: 1.7417
Epoch 50/50 | Generator Loss: 1.1928 | Discriminator Loss: 1.1307
```



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```
Epoch 48/50 | Generator Loss: 1.1319 | Discriminator Loss: 1.0681
Epoch 49/50 | Generator Loss: 1.0524 | Discriminator Loss: 1.7417
Epoch 50/50 | Generator Loss: 1.1928 | Discriminator Loss: 1.1307
```

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