TF & KERAS. РОБОТА із ЗОБРАЖЕННЯМИ

Файл: TF_KERAS_Image_06_001

Створення простої GAN мережі. Генерування MNIST подібних зображень

Example from Khoma

```
# Реалізація для GOOGLE COLAB
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
import sys
sys.path.append('/content/drive/MyDrive/Colab_Notebooks/VIP_2024_LEC/2024_CG_DIP/'
)
```

```
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow.keras import layers, Model
from tensorflow.keras.datasets import mnist
from tensorflow.keras.layers import Input, Dense, Reshape, Flatten, Dropout,
LeakyReLU, Conv2D, Conv2DTranspose, BatchNormalization, ReLU, Activation
from tensorflow.keras.callbacks import CSVLogger, ModelCheckpoint, EarlyStopping
from utils.callbacks import SaveImages
```

ГЕНЕРАТОР / ДИСКРИМИНАТОР

```
def Generator(seed_size):
    input = Input(shape=(seed_size,))

    x = Dense(7 * 7 * 256)(input) # 100 -> 7x7x256 = 12544
    x = BatchNormalization()(x)
    x = LeakyReLU()(x)

    x = Reshape((7, 7, 256))(x) # 12544 -> 7x7x256

    x = Conv2DTranspose(128, kernel_size=(5, 5), strides=(1, 1), padding="same")
(x) # 7x7x256 -> 7x7x128
    x = BatchNormalization()(x)
    x = LeakyReLU()(x)

    x = Conv2DTranspose(64, kernel_size=(5, 5), strides=(2, 2), padding="same")(x)
# 7x7x128 -> 14x14x64
    x = BatchNormalization()(x)
```

```
    x = LeakyReLU()(x)

    x = Conv2DTranspose(1, kernel_size=(5, 5), strides=(2, 2), padding="same")(x)
# 14x14x64 -> 28x28x1
    output = Activation("tanh")(x) # [-1, 1]

    return Model(input, output, name="Generator")

def Discriminator(image_shape):
    input = Input(shape=image_shape)

    x = Conv2D(64, (5, 5), strides=(2, 2), padding="same")(input)  # 28x28x1 ->
14x14x64
    x = LeakyReLU()(x)
    x = Dropout(0.3)(x)

    x = Conv2D(128, kernel_size=(5, 5), strides=(2, 2), padding="same")(x) #
14x14x64 -> 7x7x128
    x = LeakyReLU()(x)
    x = Dropout(0.3)(x)

    x = Flatten()(x) # 7x7x128 -> 6272

    x = Dense(1)(x) # 6272 -> 1
    output = Activation("sigmoid")(x) # [0, 1]

    return Model(input, output, name="Discriminator")
```

GAN

```
# Custom GAN Model
class GAN(tf.keras.Model):
    def __init__(self, generator, discriminator, seed_size):
        super(GAN, self).__init__()
        self.generator = generator
        self.discriminator = discriminator
        self.seed_size = seed_size

        self.generator_loss_tracker =
tf.keras.metrics.Mean(name="generator_loss")
        self.discriminator_loss_tracker =
tf.keras.metrics.Mean(name="discriminator_loss")

    def compile(self, generator_optimizer, discriminator_optimizer, loss_fn):
        super(GAN, self).compile()
        self.generator_optimizer = generator_optimizer
        self.discriminator_optimizer = discriminator_optimizer
        self.loss_fn = loss_fn

    @property
    def metrics(self):
        return [
            self.generator_loss_tracker,
            self.discriminator_loss_tracker
        ]
```

```
    def generator_loss(self, fake_output):
        return self.loss_fn(tf.ones_like(fake_output), fake_output) # Means how
well the generator fooled the discriminator

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

    @tf.function
    def train_step(self, data):
        batch_size = tf.shape(data)[0]

        seed = tf.random.normal(shape=(batch_size, self.seed_size))

        with tf.GradientTape() as generator_tape, tf.GradientTape() as
discriminator_tape:
            generated_image = self.generator(seed, training = True)

            real_output = self.discriminator(data, training = True)
            fake_output = self.discriminator(generated_image, training = True)

            generator_loss = self.generator_loss(fake_output)
            discriminator_loss = self.discriminator_loss(real_output,
fake_output)

        generator_grad = generator_tape.gradient(generator_loss,
self.generator.trainable_variables)
        discriminator_grad = discriminator_tape.gradient(discriminator_loss,
self.discriminator.trainable_variables)

        self.generator_optimizer.apply_gradients(zip(generator_grad,
self.generator.trainable_variables))
        self.discriminator_optimizer.apply_gradients(zip(discriminator_grad,
self.discriminator.trainable_variables))

        self.generator_loss_tracker.update_state(generator_loss)
        self.discriminator_loss_tracker.update_state(discriminator_loss)

        return {
            "generator_loss": self.generator_loss_tracker.result(),
            "discriminator_loss": self.discriminator_loss_tracker.result()
        }


    @tf.function
    def test_step(self, data):
        batch_size = tf.shape(data)[0]

        seed = tf.random.normal(shape=(batch_size, self.seed_size))

        generated_image = self.generator(seed, training = False)

        real_output = self.discriminator(data, training = False)
```

```
        fake_output = self.discriminator(generated_image, training = False)

        generator_loss = self.generator_loss(fake_output)
        discriminator_loss = self.discriminator_loss(real_output, fake_output)

        self.generator_loss_tracker.update_state(generator_loss)
        self.discriminator_loss_tracker.update_state(discriminator_loss)

        return {
            "generator_loss": self.generator_loss_tracker.result(),
            "discriminator_loss": self.discriminator_loss_tracker.result()
        }

    @tf.function
    def call(self, inputs):
        image  = self.generator(inputs, training=False)
        score = self.discriminator(image, training=False)

        return image, score
```

ПАРАМЕТРИ

```
# Constants
IMAGE_SHAPE = (28, 28, 1)
BATCH_SIZE = 100
EPOCHS = 25
SEED_SIZE = 100

CALLBACK_NUM_ROWS = 4
CALLBACK_NUM_COLS = 7
CALLBACK_MARGIN = 16

CALLBACK_FIXED_SEED = tf.random.normal(shape=(CALLBACK_NUM_ROWS *
CALLBACK_NUM_COLS, SEED_SIZE))
IMAGE_FIXED_SEED = tf.random.normal(shape=(10, SEED_SIZE))

GAN_WEIGHTS_PATH = "mnist_gan.weights.h5"
```

ЗАВАНТАЖЕННЯ ДАТАСЕТУ MNIST

```
# Load and preprocess MNIST data
(x_train, _), (_, _) = mnist.load_data()

train_ds = x_train[:50000] # Train on 50,000 examples
val_ds = x_train[50000:] # Validate on 10,000 examples

TRAIN_BUFFER_SIZE = train_ds.shape[0]
VAL_BUFFER_SIZE = val_ds.shape[0]

train_ds = train_ds.reshape(train_ds.shape[0], 28, 28, 1).astype("float32")
val_ds = val_ds.reshape(val_ds.shape[0], 28, 28, 1).astype("float32")

train_ds = (train_ds / 127.5) - 1.0
val_ds = (val_ds / 127.5) - 1.0
```

```
train_ds =
tf.data.Dataset.from_tensor_slices(train_ds).shuffle(TRAIN_BUFFER_SIZE).batch(BATC
H_SIZE)
val_ds =
tf.data.Dataset.from_tensor_slices(val_ds).shuffle(VAL_BUFFER_SIZE).batch(BATCH_SI
ZE)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
•[1m11490434/11490434•[0m •[32m--------------------•[0m•[37m•[0m •[1m0s•[0m
0us/step
```

Завантаження попередньо визначених ваг (якщо є)

+ КОМПІЛЯЦІЯ GAN

```
# Build generator and discriminator
generator = Generator(SEED_SIZE)
discriminator = Discriminator(IMAGE_SHAPE)

generator.build(input_shape=(None, SEED_SIZE))
discriminator.build(input_shape=(None, 28, 28, 1))

gan = GAN(generator, discriminator, SEED_SIZE)
gan.build(input_shape=(None, SEED_SIZE))

# load weights if file exists
if tf.io.gfile.exists(GAN_WEIGHTS_PATH):
  gan.load_weights(GAN_WEIGHTS_PATH)
  print("Loaded weights from file")

gan.compile(
  generator_optimizer=tf.keras.optimizers.Adam(learning_rate=1e-4),
  discriminator_optimizer=tf.keras.optimizers.Adam(learning_rate=1e-4),
  loss_fn=tf.keras.losses.BinaryCrossentropy(from_logits=False)
)

gan.summary()
# gan.generator.summary()
# gan.discriminator.summary()
```

Model: "gan"

Layer (type)	Output Shape	Param
Generator (Functional)	(None, 28, 28, 1)	2,343,68
Discriminator (Functional)	(None, 1)	212,86

```
Total params: 2,556,546 (9.75 MB)
```

```
Trainable params: 2,531,074 (9.66 MB)
```

```
Non-trainable params: 25,472 (99.50 KB)
```

ТРЕНЕРУВАННЯ GAN

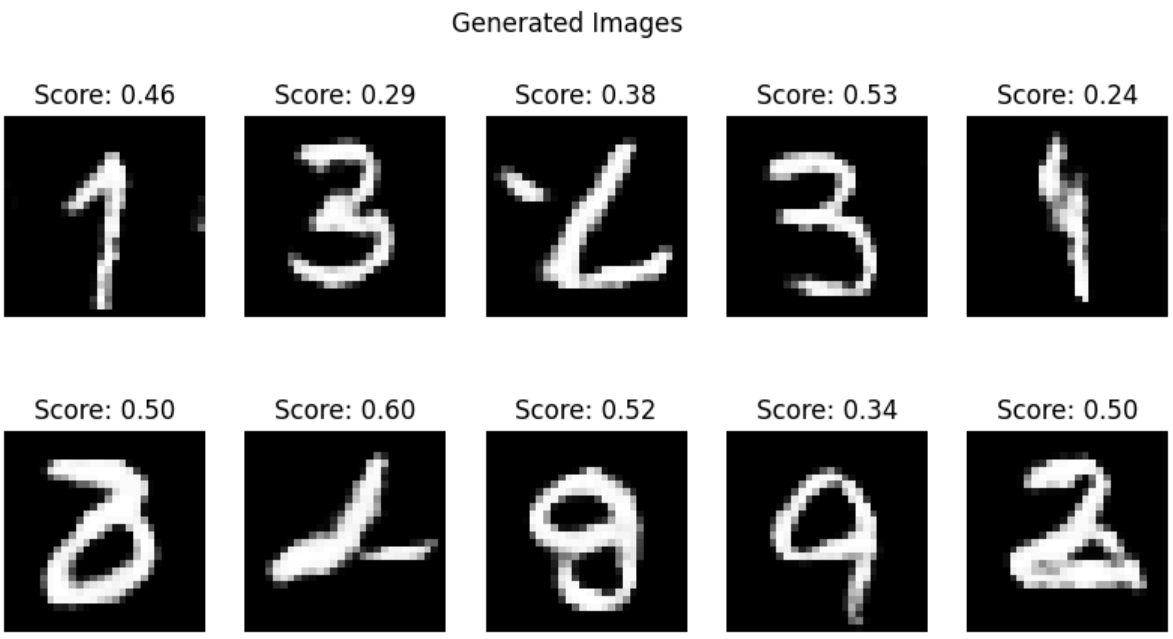
```
# Train the GAN model
gan.fit(
    train_ds,
    validation_data=val_ds,
    epochs=100,
    batch_size=BATCH_SIZE,
    initial_epoch=10, # should be last_epoch_saved + 1 or 0 of no weights saved
    callbacks=[
        CSVLogger("mnist_gan.csv", append=True),
        ModelCheckpoint(GAN_WEIGHTS_PATH, monitor="generator_loss", mode='min',
save_best_only=True, save_weights_only=True),
        SaveImages(noise=CALLBACK_FIXED_SEED, num_rows=CALLBACK_NUM_ROWS,
num_cols=CALLBACK_NUM_COLS, margin=CALLBACK_MARGIN)
    ]
)
```

```
Epoch 11/100
•[1m500/500•[0m •[32m--------------------•[0m•[37m•[0m •[1m9s•[0m 18ms/step -
discriminator_loss: 1.0198 - generator_loss: 1.2659 - val_discriminator_loss:
0.8709 - val_generator_loss: 1.4655

Epoch 100/100
•[1m500/500•[0m •[32m--------------------•[0m•[37m•[0m •[1m10s•[0m 18ms/step -
discriminator_loss: 1.2770 - generator_loss: 0.8598 - val_discriminator_loss:
1.2124 - val_generator_loss: 0.9263
```

ЗГЕНЕРОВАНІ ЗОБРАЖЕННЯ

```
image, score = gan.predict(IMAGE_FIXED_SEED)

# show 10 images with the discriminator scores
fig, axs = plt.subplots(2, 5, figsize=(10, 5))
fig.suptitle("Generated Images")
for i in range(10):
    row = i // 5
    col = i % 5
    axs[row, col].imshow((image[i, :, :, 0] + 1.0) * 127.5, cmap="gray")
    axs[row, col].axis("off")
    axs[row, col].set_title(f"Score: {score[i][0]:.2f}")
```

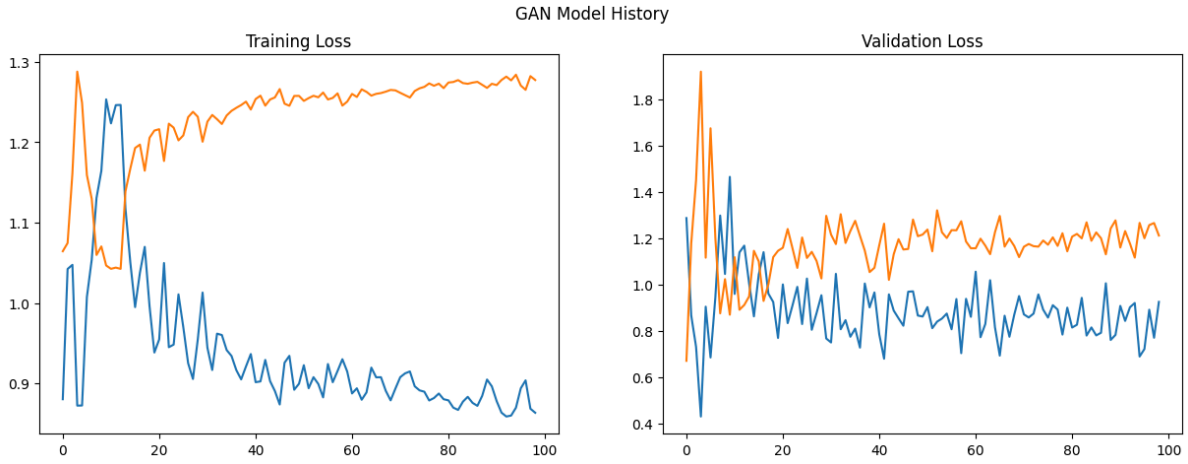
```
•[1m1/1•[0m •[32m--------------------•[0m•[37m•[0m •[1m0s•[0m 18ms/step
```



МЕТРИКИ

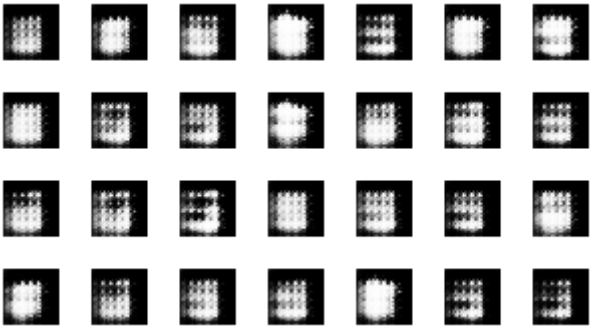
```
# plot history of the model on graph
import pandas as pd

def read_logs(log_path):
    df = pd.read_csv(log_path)
    return df

df = read_logs("mnist_gan.csv")

fig, axs = plt.subplots(1, 2, figsize=(15, 5))
fig.suptitle("GAN Model History")
axs[0].plot(df["generator_loss"], label="generator_loss")
axs[0].plot(df["discriminator_loss"], label="discriminator_loss")
axs[0].set_title("Training Loss")

axs[1].plot(df["val_generator_loss"], label="val_generator_loss")
axs[1].plot(df["val_discriminator_loss"], label="val_discriminator_loss")
axs[1].set_title("Validation Loss")
```

```
Text(0.5, 1.0, 'Validation Loss')
```



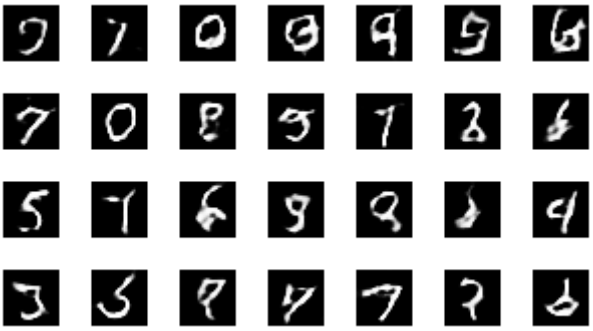
ПОСЛІДОВНІСТЬ ЗГЕНРОВАНИХ ЗОБРАЖЕННЬ

Епоха 01

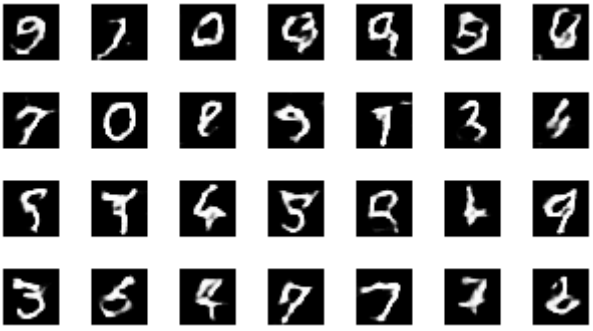


Епоха 10

Епоха 20

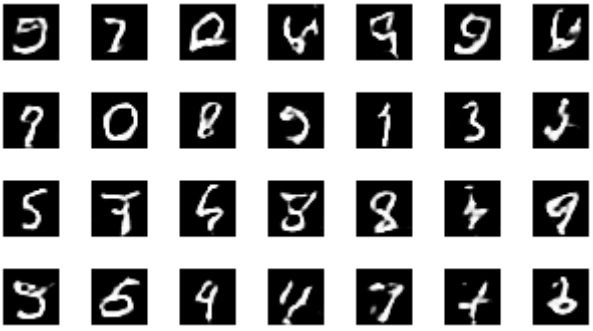


Епоха 30

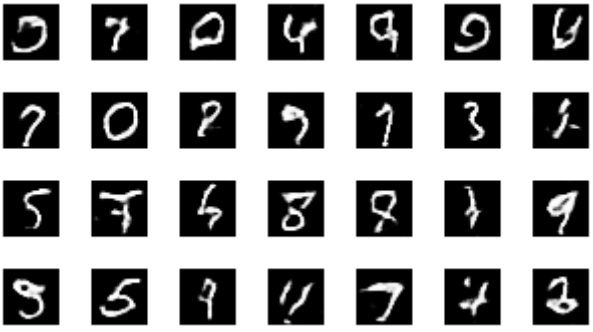


Епоха 40

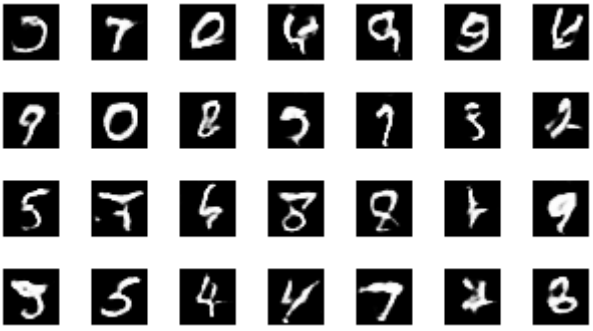
Епоха 50



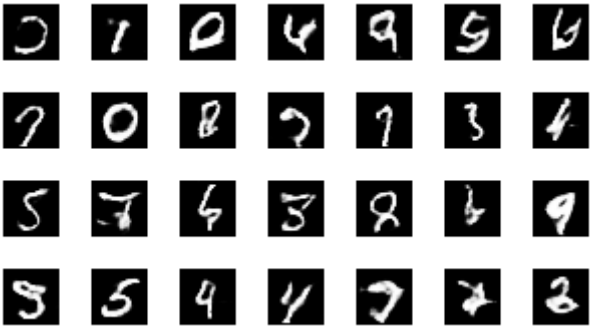
Епоха 60



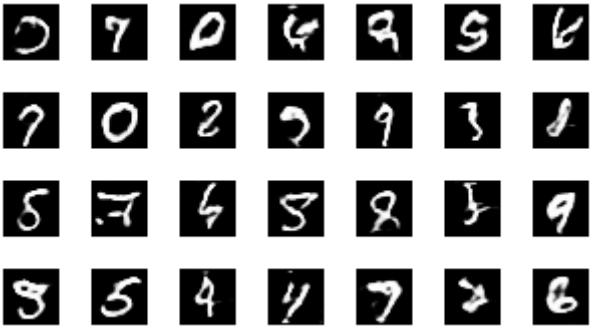
Епоха 70



Епоха 80



Епоха 90



Епоха 99