

```

import tensorflow as tf
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense
from tensorflow.keras.layers import Activation
import matplotlib.pyplot as plt

(x_train, y_train), (x_test, y_test) =
tf.keras.datasets.mnist.load_data()

x_train = x_train.astype('float32')
x_test = x_test.astype('float32')

gray_scale = 255
x_train /= gray_scale
x_test /= gray_scale

print("--- Data Structure ---")
print("Feature matrix (train):", x_train.shape)
print("Target matrix (train):", y_train.shape)
print("Feature matrix (test):", x_test.shape)
print("Target matrix (test):", y_test.shape)
print("-----\n")

print("--- Visualizing Data (Close window to continue) ---")
fig, ax = plt.subplots(10, 10)
k = 0
for i in range(10):
    for j in range(10):
        ax[i][j].imshow(x_train[k].reshape(28, 28), aspect='auto',
cmap='gray')
        k += 1
plt.show()
print("-----\n")

model = Sequential([
    # reshape 28 row * 28 column data to 28*28 rows
    Flatten(input_shape=(28, 28)),

    # dense layer 1
    Dense(256, activation='sigmoid'),

    # dense layer 2
    Dense(128, activation='sigmoid'),

    # output layer
    Dense(10, activation='sigmoid'),
])

```

```

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

print("--- Model Summary ---")
model.summary()
print("-----\n")

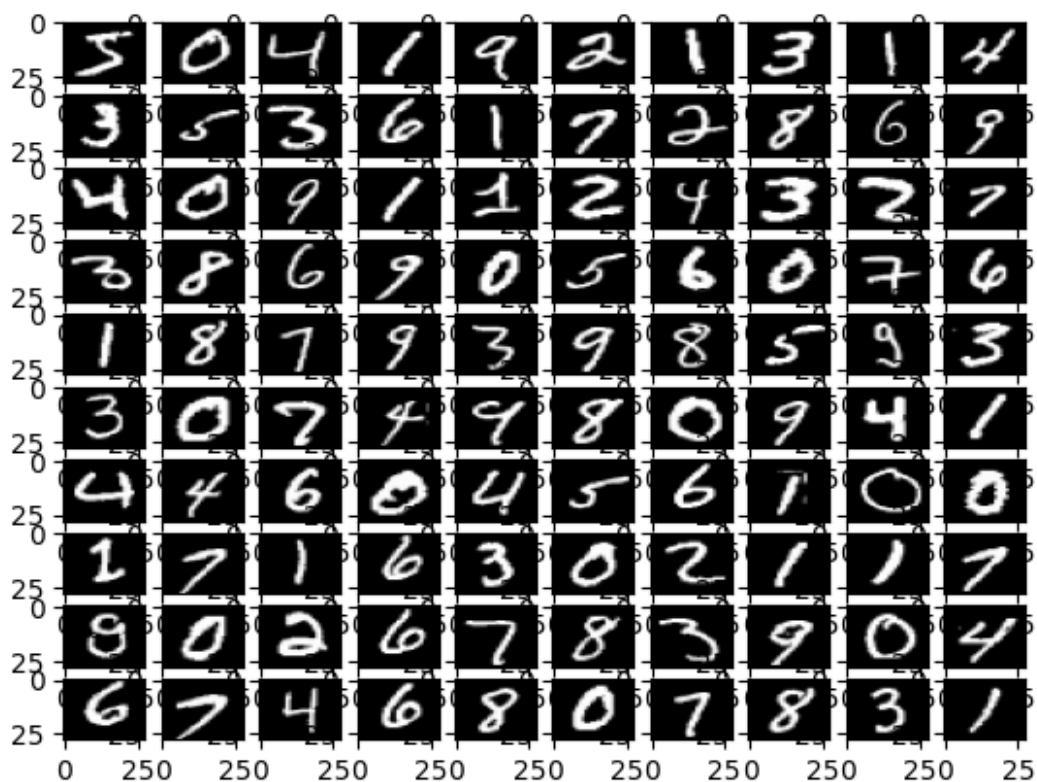
print("--- Training Model ---")
model.fit(x_train, y_train, epochs=10,
        batch_size=2000,
        validation_split=0.2)
print("-----\n")

print("--- Evaluating Model ---")
results = model.evaluate(x_test, y_test, verbose=0)
print('Test loss, Test acc:', results)
print("-----\n")

--- Data Structure ---
Feature matrix (train): (60000, 28, 28)
Target matrix (train): (60000,)
Feature matrix (test): (10000, 28, 28)
Target matrix (test): (10000,)
-----

--- Visualizing Data (Close window to continue) ---

```



--- Model Summary ---

Model: "sequential_2"

| Layer (type) Param # | Output Shape | |
|----------------------------|--------------|--|
| flatten_2 (Flatten) 0 | (None, 784) | |
| dense_6 (Dense) 200,960 | (None, 256) | |
| dense_7 (Dense) 32,896 | (None, 128) | |
| dense_8 (Dense) | (None, 10) | |

1,290 |

Total params: 235,146 (918.54 KB)

Trainable params: 235,146 (918.54 KB)

Non-trainable params: 0 (0.00 B)

--- Training Model ---

Epoch 1/10

24/24 1s 14ms/step - accuracy: 0.2409 - loss: 2.2600 - val_accuracy: 0.6622 - val_loss: 1.7788

Epoch 2/10

24/24 0s 10ms/step - accuracy: 0.6961 - loss: 1.6065 - val_accuracy: 0.8072 - val_loss: 1.0894

Epoch 3/10

24/24 0s 10ms/step - accuracy: 0.7974 - loss: 1.0001 - val_accuracy: 0.8602 - val_loss: 0.7088

Epoch 4/10

24/24 0s 11ms/step - accuracy: 0.8530 - loss: 0.6800 - val_accuracy: 0.8838 - val_loss: 0.5252

Epoch 5/10

24/24 0s 11ms/step - accuracy: 0.8787 - loss: 0.5205 - val_accuracy: 0.8990 - val_loss: 0.4267

Epoch 6/10

24/24 0s 19ms/step - accuracy: 0.8953 - loss: 0.4310 - val_accuracy: 0.9050 - val_loss: 0.3701

Epoch 7/10

24/24 0s 12ms/step - accuracy: 0.9043 - loss: 0.3752 - val_accuracy: 0.9129 - val_loss: 0.3325

Epoch 8/10

24/24 0s 11ms/step - accuracy: 0.9108 - loss: 0.3392 - val_accuracy: 0.9179 - val_loss: 0.3061

Epoch 9/10

24/24 0s 17ms/step - accuracy: 0.9165 - loss: 0.3109 - val_accuracy: 0.9212 - val_loss: 0.2876

Epoch 10/10

24/24 0s 14ms/step - accuracy: 0.9197 - loss: 0.2938 - val_accuracy: 0.9266 - val_loss: 0.2705

--- Evaluating Model ---

Test loss, Test acc: [0.27433285117149353, 0.9229999780654907]