```
# Implementing feedforward neural networks with Keras and TensorFlow
# import the necessary packages
import numpy as np
import tensorflow as tf
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
import matplotlib.pyplot as plt
```

```
# grab the MNIST dataset (if this is your first time using this
# dataset then the 11MB download may take a minute)

print("[INFO] accessing MNIST...")
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train = x_train.reshape((x_train.shape[0], -1)).astype('float32') / 255
x_test = x_test.reshape((x_test.shape[0], -1)).astype('float32') / 255
```

```
[INFO] accessing MNIST...
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-data
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 1s 0us/step
```

```
# Re-load the MNIST dataset to ensure y_train and y_test are original intege
# before one-hot encoding, as multiple runs of to_categorical can lead to in
# We only need the y labels, so we use _ for x.
(_, y_train_original), (_, y_test_original) = mnist.load_data()

# One-hot encode the labels
y_train = tf.keras.utils.to_categorical(y_train_original, num_classes=10)
y_test = tf.keras.utils.to_categorical(y_test_original, num_classes=10)


# Each data point in the MNIST dataset has an integer label in the range [0,
# A label with a value of 0 indicates that the corresponding image contains
# that the corresponding image contains the number eight.
```

```
# Step 3: Define the network architecture
model = Sequential([
    tf.keras.Input(shape=(784,)),
    Dense(64, activation='relu'),
    Dense(64, activation='relu'),
    Dense(64, activation='relu'),
    Dense(10, activation='softmax')
])
```

```
# Step 4: Compile the model
model.compile(optimizer='sgd', loss='categorical_crossentropy', metrics=['ac
# Step 5: Train the model
H = model.fit(x_train, y_train, epochs=15, batch_size=32, validation_data=(x
```

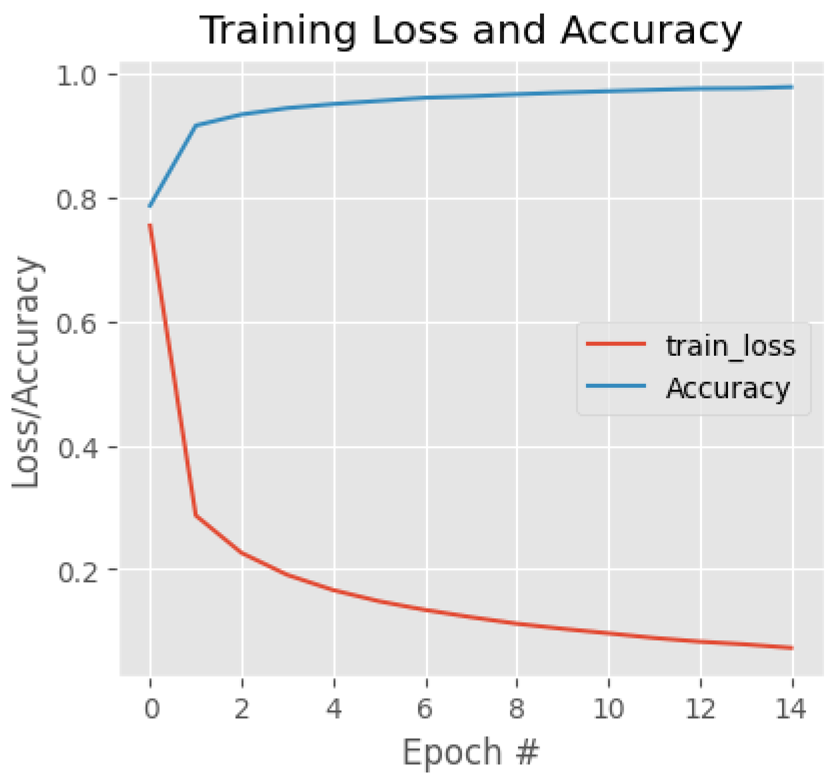
```
Epoch 1/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.6137 - loss: 1.2998
Epoch 2/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9109 - loss: 0.3076
Epoch 3/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9298 - loss: 0.2459
Epoch 4/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9451 - loss: 0.1935
Epoch 5/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9513 - loss: 0.1673
Epoch 6/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9549 - loss: 0.1518
Epoch 7/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9603 - loss: 0.1347
Epoch 8/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9636 - loss: 0.1231
Epoch 9/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9677 - loss: 0.1100
Epoch 10/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9700 - loss: 0.1020
Epoch 11/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9710 - loss: 0.1006
Epoch 12/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 9s 3ms/step - accuracy: 0.9738 - loss: 0.0892
Epoch 13/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9775 - loss: 0.0799
Epoch 14/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9776 - loss: 0.0754
Epoch 15/15
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9786 - loss: 0.0733
```

```
# Step 6: Evaluate the network
test_loss, test_accuracy = model.evaluate(x_test, y_test)
print(f'Test accuracy: {test_accuracy*100:.2f}%')
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.9652 - loss: 0.1144
Test accuracy: 96.98%
```

```
# Step 7: Plot the training loss and accuracy
plt.style.use("ggplot")
plt.figure(figsize=(10, 4))
plt.subplot(1, 2, 1)
plt.plot(H.history['loss'], label="train_loss")
plt.plot(H.history['accuracy'], label="Accuracy")
plt.title("Training Loss and Accuracy")
plt.xlabel("Epoch #")
plt.ylabel("Loss/Accuracy")
plt.legend()
```

```
<matplotlib.legend.Legend at 0x799f7350b500>
```



```
Start coding or generate with AI.
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