```
'''
Problem Statement -- Implementing Feedforward neural networks with
Keras and TensorFlow
a. Import the necessary packages
b. Load the training and testing data (MNIST/CIFAR10)
c. Define the network architecture using Keras
d. Train the model using SGD
e. Evaluate the network
f. Plot the training loss and accuracy
'''

# a. importing packages
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
import random

# b. LOAD THE TRAINING AND TESTING DATA (MNIST)
mnist = tf.keras.datasets.mnist
(x_train,y_train),(x_test,y_test) = mnist.load_data()

x_train = x_train/255
x_test = x_test/255
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-
keras-datasets/mnist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

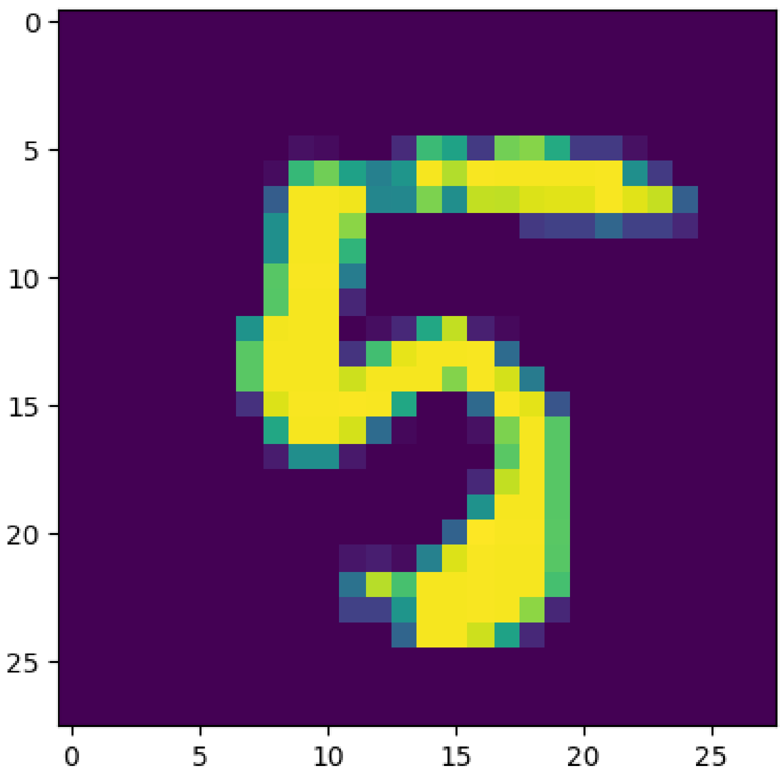
```
# c. DEFINE THE NETWORK ARCHITECTURE USING KERAS ->
model =keras.Sequential([
    keras.layers.Flatten(input_shape=(28,28)),
    keras.layers.Dense(128,activation='relu'),
    keras.layers.Dense(10,activation='softmax')
])

model.summary()
```

```
/usr/local/lib/python3.12/dist-packages/keras/src/layers/reshaping/
flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an
`Input(shape)` object as the first layer in the model instead.
  super().__init__(**kwargs)
```

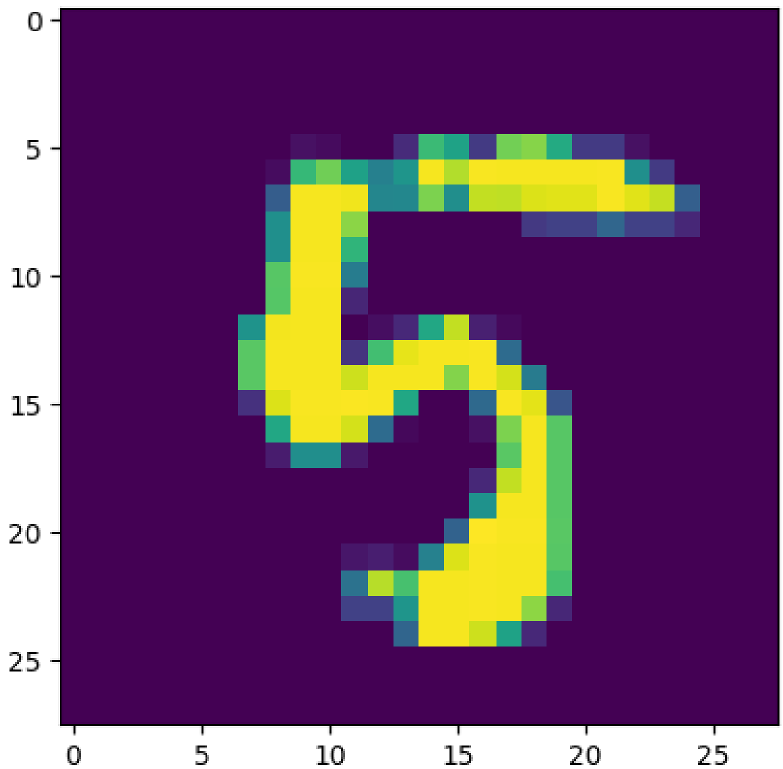
```
Model: "sequential"

┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━
━━━━━┓
┃ Layer (type)                    ┃ Output Shape           ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━
━━━━━┩
```

```
│ flatten (Flatten)                    │ (None, 784)                │
0 │
├──────────────────────────────────────┼────────────────────────────┼────────
──────┤
│ dense (Dense)                        │ (None, 128)                │
100,480 │
├──────────────────────────────────────┼────────────────────────────┼────────
──────┤
│ dense_1 (Dense)                      │ (None, 10)                 │
1,290 │
└──────────────────────────────────────┴────────────────────────────┴────────
──────┘

 Total params: 101,770 (397.54 KB)

 Trainable params: 101,770 (397.54 KB)

 Non-trainable params: 0 (0.00 B)

# d.TRAIN THE MODEL USING SGD
model.compile(optimizer='sgd',
  loss='sparse_categorical_crossentropy',
  metrics=['accuracy']
)

history=model.fit(x_train,y_train,validation_data=(x_test,y_test),epoc
hs=3)

Epoch 1/3
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.7399 - loss:
1.0029 - val_accuracy: 0.9069 - val_loss: 0.3518
Epoch 2/3
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9053 - loss:
0.3476 - val_accuracy: 0.9197 - val_loss: 0.2899
Epoch 3/3
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 3ms/step - accuracy: 0.9189 - loss:
0.2963 - val_accuracy: 0.9298 - val_loss: 0.2586

# e. EVALUATE THE NETWORK
test_loss,test_acc = model.evaluate(x_test,y_test)
print("Loss=%.3f" %test_loss)
print("Accuracy=%.3f" %test_acc)

n=random.randint(0,9999)
plt.imshow(x_test[n])
plt.show()
predicted_value = model.predict(x_test)
plt.imshow(x_test[n])
plt.show()

print("Predicted Value:",predicted_value[n])
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.9193 - loss:
0.2955
Loss=0.259
Accuracy=0.930
```

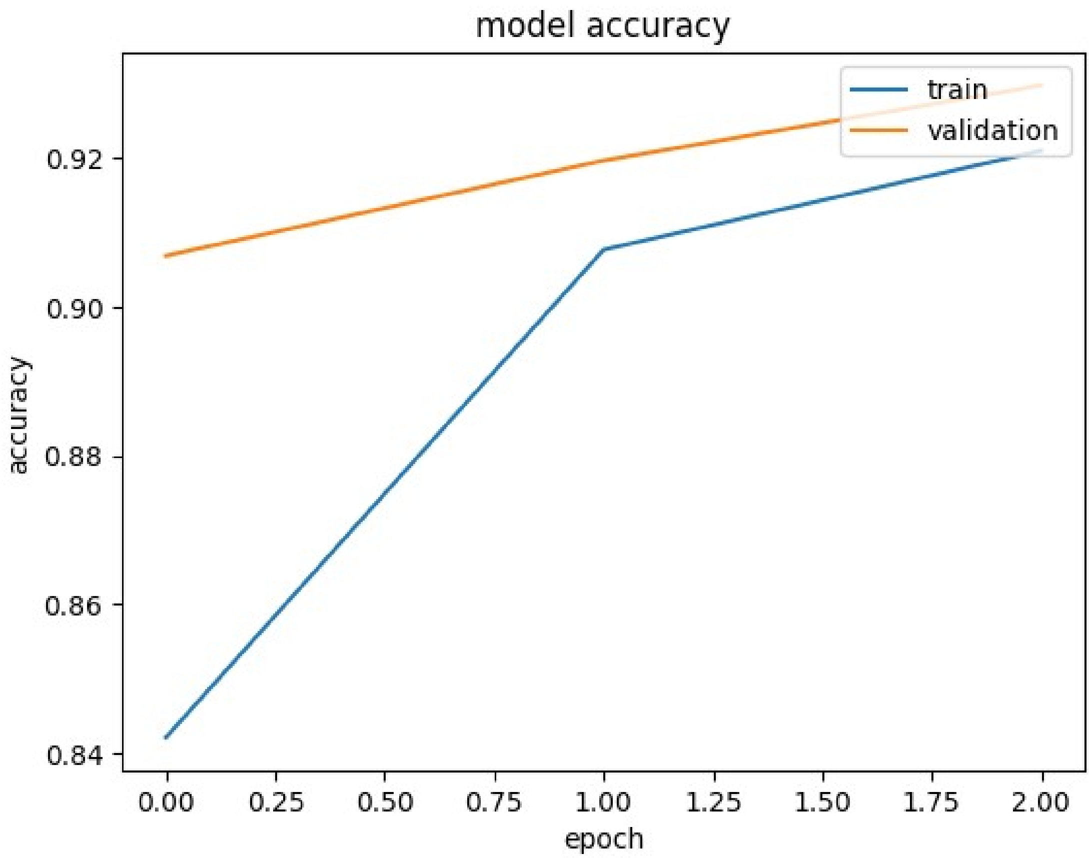



```
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step
```

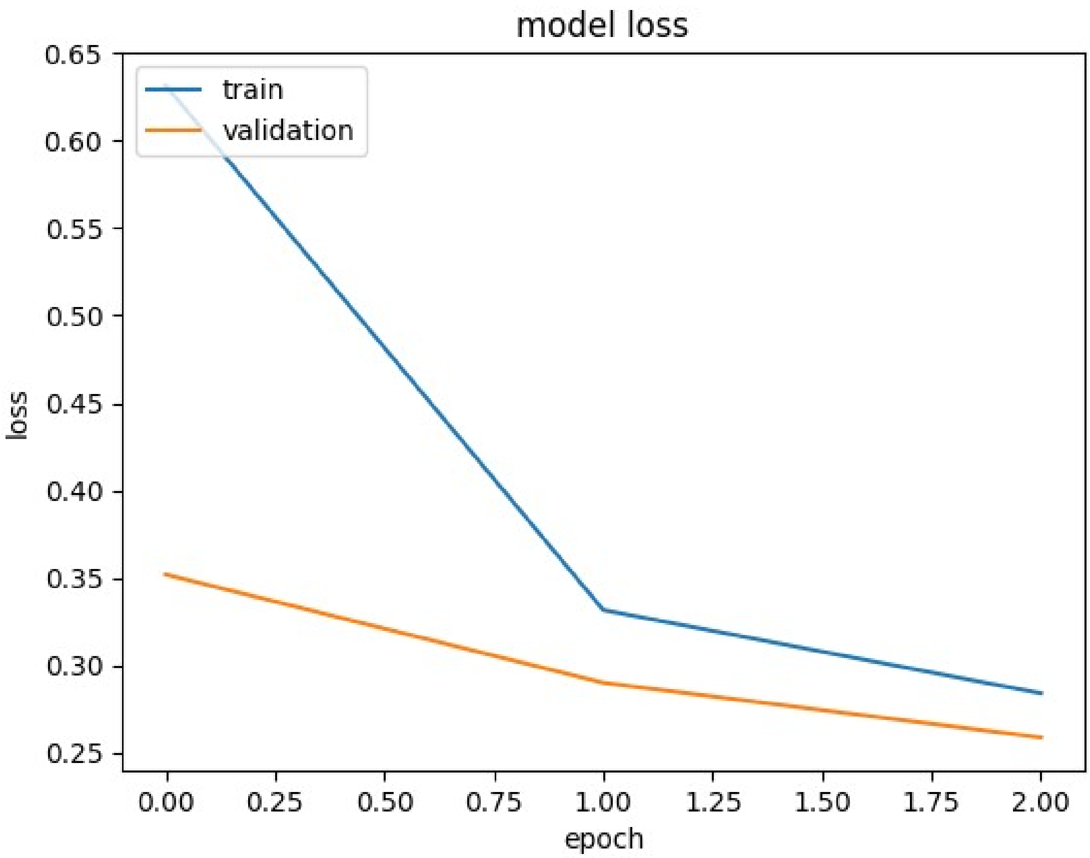



```
Predicted Value: [5.0470990e-04 3.6435162e-07 5.7552425e-05
2.9780556e-04 1.9890675e-02
 9.0380585e-01 2.3467431e-03 9.1786347e-07 7.1932137e-02 1.1632276e-
03]
```

```python
# f. PLOT THE TRAINING LOSS AND ACCURACY
   # plotting the training accuracy
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper right')
plt.show()
```




```python
# plotting the training loss

plt.plot(history.history["loss"])
plt.plot(history.history["val_loss"])
plt.title("model loss")
plt.ylabel("loss")
plt.xlabel("epoch")
plt.legend(["train", "validation"], loc="upper left")
plt.show()
```


model loss
train
validation
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
loss
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
epoch