Problem Statement 3: Build the Image classification model by dividing the model into following 4 stages: Loading and preprocessing the image data Defining the model's architecture Training the model Estimating the model's performance

```
#Importing Libraries
import numpy as np
import pandas as pd
import random
import tensorflow as tf
import matplotlib.pyplot as plt
from sklearn.metrics import accuracy_score

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Flatten, Conv2D, Dense, MaxPooling2D
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.datasets import mnist


(X_train, y_train), (X_test, y_test) = mnist.load_data()
```

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

```
print(X_train.shape)
(60000, 28, 28)
```

```
(60000, 28, 28)
(60000, 28, 28)
```

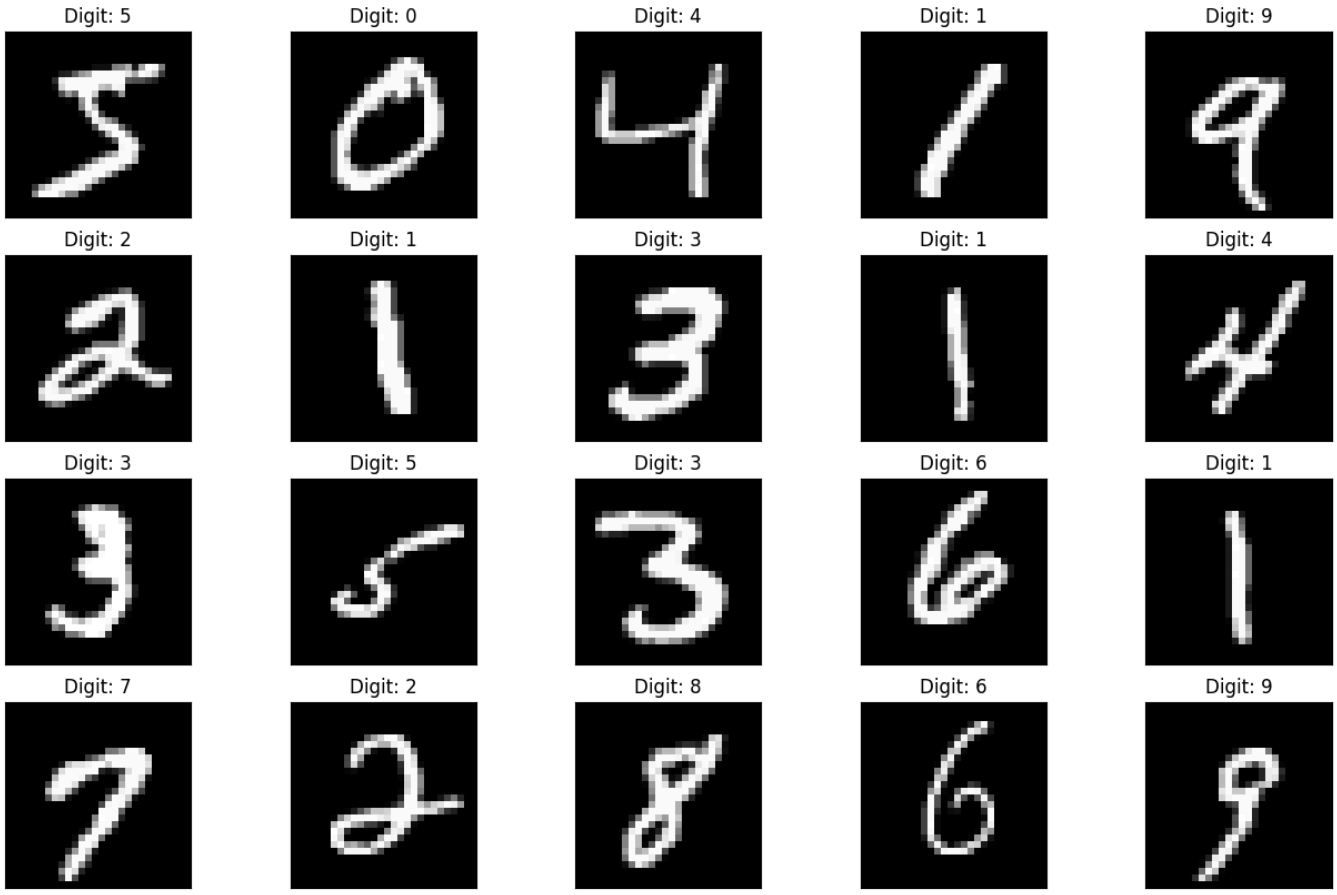
```
X_train[0].min(), X_train[0].max()
(0, 255)
```

```
(0, 255)
```

```
X_train = (X_train - 0.0) / (255.0 - 0.0)
X_test = (X_test - 0.0) / (255.0 - 0.0)
X_train[0].min(), X_train[0].max()
```

```
(0.0, 0.00392156862745098)
```

```
def plot_digit(image, digit, plt, i):
    plt.subplot(4, 5, i + 1)
    plt.imshow(image, cmap=plt.get_cmap('gray'))
    plt.title(f"Digit: {digit}")
    plt.xticks([])
    plt.yticks([])
plt.figure(figsize=(16, 10))
for i in range(20):
    plot_digit(X_train[i], y_train[i], plt, i)
plt.show()
```




```
X_train = X_train.reshape((X_train.shape + (1,)))
X_test = X_test.reshape((X_test.shape + (1,)))
```

```
y_train[0:20]
```

```
array([5, 0, 4, 1, 9, 2, 1, 3, 1, 4, 3, 5, 3, 6, 1, 7, 2, 8, 6, 9],
      dtype=uint8)
```

```
model = Sequential([
    Conv2D(32, (3, 3), activation="relu", input_shape=(28, 28, 1)),
    MaxPooling2D((2, 2)),
    Flatten(),
    Dense(100, activation="relu"),
    Dense(10, activation="softmax")
])
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an `input_shape`/`
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
optimizer = SGD(learning_rate=0.01, momentum=0.9)
model.compile(
    optimizer=optimizer,
    loss="sparse_categorical_crossentropy",
    metrics=["accuracy"]
)
model.summary()
```

```
Model: "sequential_1"
```

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d (MaxPooling2D)	(None, 13, 13, 32)	0
flatten (Flatten)	(None, 5408)	0
dense (Dense)	(None, 100)	540,900
dense_1 (Dense)	(None, 10)	1,010

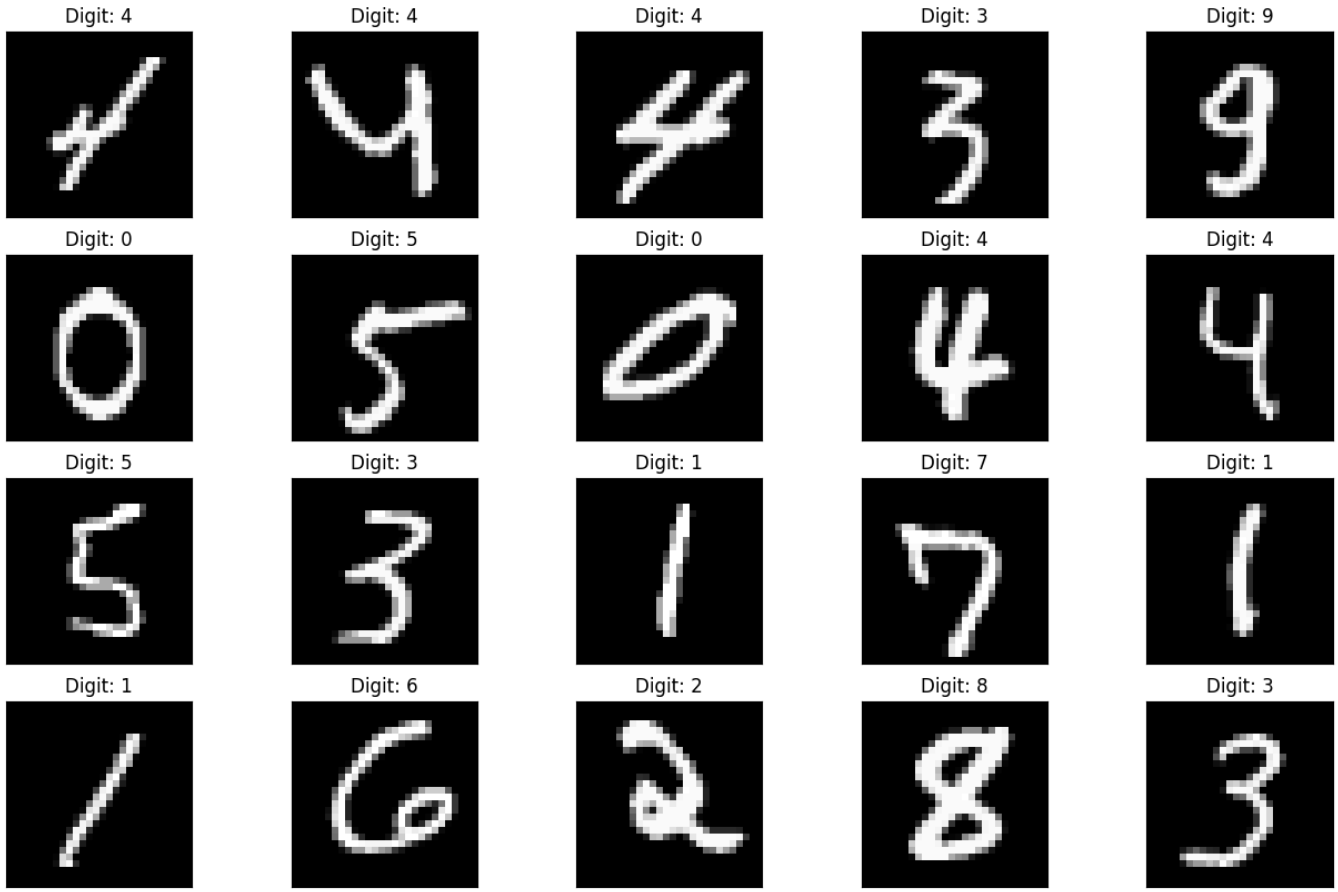
Total params: 542,230 (2.07 MB)

```
model.fit(X_train, y_train, epochs=10, batch_size=32)
```

```
Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 32s 17ms/step - accuracy: 0.8665 - loss: 0.4392
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 40s 16ms/step - accuracy: 0.9725 - loss: 0.0895
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 32s 17ms/step - accuracy: 0.9845 - loss: 0.0534
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 40s 17ms/step - accuracy: 0.9893 - loss: 0.0367
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 41s 17ms/step - accuracy: 0.9917 - loss: 0.0271
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 31s 16ms/step - accuracy: 0.9940 - loss: 0.0188
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 32s 17ms/step - accuracy: 0.9960 - loss: 0.0143
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 38s 16ms/step - accuracy: 0.9972 - loss: 0.0105
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 29s 15ms/step - accuracy: 0.9977 - loss: 0.0086
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 29s 15ms/step - accuracy: 0.9984 - loss: 0.0063
<keras.src.callbacks.history.History at 0x7e5a2d346440>
```

```
plt.figure(figsize=(16, 10))
for i in range(20):
    image = random.choice(X_test).squeeze()
    digit = np.argmax(model.predict(image.reshape((1, 28, 28, 1)))[0], axis=-1)
    plot_digit(image, digit, plt, i)
plt.show()
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 94ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 32ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 33ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 32ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 29ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 29ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 35ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 29ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 26ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 22ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 25ms/step
```




```
predictions = np.argmax(model.predict(X_test), axis=-1)
accuracy_score(y_test, predictions)
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 3s 9ms/step
0.9861
```

```
score = model.evaluate(X_test, y_test, verbose=0)
print('Test loss:', score[0])
```

```
Test loss: 2.6840920448303223
```

```
print('Test accuracy:', score[1])
```

```
Test accuracy: 0.11349999904632568
```

```
import matplotlib.pyplot as plt

# Train the model and store the history in 'model_log'
```

```
model_log = model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=10)

# Create a figure for the plots
fig = plt.figure(figsize=(10, 8))

# Plot model accuracy
plt.subplot(2, 1, 1)
plt.plot(model_log.history['accuracy'])
plt.plot(model_log.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='lower right')

# Plot model loss
plt.subplot(2, 1, 2)
plt.plot(model_log.history['loss'])
plt.plot(model_log.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper right')

# Adjust layout to prevent overlap
plt.tight_layout()

# Save the figure as 'model_plot.png'
fig.savefig('model_plot.png')

# Show the plot
plt.show()
```

```
Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 43s 23ms/step - accuracy: 0.1114 - loss: 2.3016 - val_accuracy: 0.1135 - val_loss: 2.3016
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 32s 17ms/step - accuracy: 0.1103 - loss: 2.3021 - val_accuracy: 0.1135 - val_loss: 2.3021
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 38s 16ms/step - accuracy: 0.1131 - loss: 2.3020 - val_accuracy: 0.1135 - val_loss: 2.3014
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 29s 16ms/step - accuracy: 0.1115 - loss: 2.3018 - val_accuracy: 0.1135 - val_loss: 2.3018
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 43s 17ms/step - accuracy: 0.1112 - loss: 2.3020 - val_accuracy: 0.1135 - val_loss: 2.3016
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 31s 17ms/step - accuracy: 0.1126 - loss: 2.3014 - val_accuracy: 0.1135 - val_loss: 2.3015
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 39s 16ms/step - accuracy: 0.1090 - loss: 2.3019 - val_accuracy: 0.1135 - val_loss: 2.3022
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 40s 15ms/step - accuracy: 0.1105 - loss: 2.3022 - val_accuracy: 0.1135 - val_loss: 2.3016
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 45s 18ms/step - accuracy: 0.1080 - loss: 2.3023 - val_accuracy: 0.1135 - val_loss: 2.3012
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 37s 15ms/step - accuracy: 0.1132 - loss: 2.3015 - val_accuracy: 0.1135 - val_loss: 2.3012
```