Handwritten Digit Recognition using CNN

This notebook builds a deep learning model using the MNIST dataset to recognize handwritten digits (0-9).

```
# Step 1: Install Required Libraries
!pip install tensorflow matplotlib seaborn
```

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```

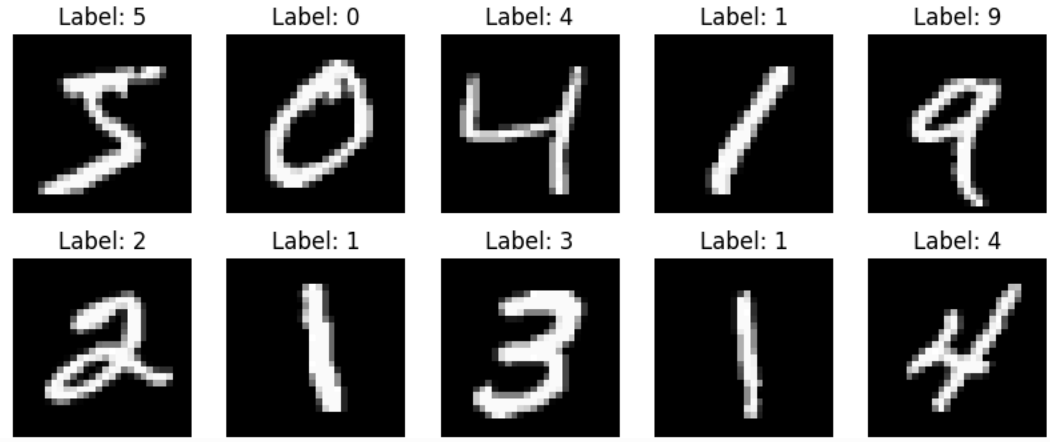
```
# Step 2: Import Libraries
import tensorflow as tf
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from sklearn.metrics import classification_report, confusion_matrix
```

```
# Step 3: Load and Explore the MNIST Dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()
print(f'Training samples: {x_train.shape[0]}, Test samples: {x_test.shape[0]}')

# Visualize a sample
plt.figure(figsize=(10, 4))
for i in range(10):
    plt.subplot(2, 5, i+1)
    plt.imshow(x_train[i], cmap='gray')
```

```
    plt.title(f"Label: {y_train[i]}")
    plt.axis('off')
plt.show()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
Training samples: 60000, Test samples: 10000
```




```
# Step 4: Preprocess the Data
# Reshape and normalize
x_train = x_train.reshape(-1, 28, 28, 1).astype("float32") / 255.0
x_test = x_test.reshape(-1, 28, 28, 1).astype("float32") / 255.0

# One-hot encode labels
y_train_cat = to_categorical(y_train, 10)
y_test_cat = to_categorical(y_test, 10)



# Step 5: Build the CNN Model
model = Sequential([
    Conv2D(32, kernel_size=(3,3), activation='relu', input_shape=(28,28,1)),
    MaxPooling2D(pool_size=(2,2)),
    Conv2D(64, kernel_size=(3,3), activation='relu'),
    MaxPooling2D(pool_size=(2,2)),
    Flatten(),
    Dense(128, activation='relu'),
    Dropout(0.3),
    Dense(10, activation='softmax')
])
model.summary()
```

```
/usr/local/lib/python3.11/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an `input_shape`/`
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d (MaxPooling2D)	(None, 13, 13, 32)	0
conv2d_1 (Conv2D)	(None, 11, 11, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(None, 5, 5, 64)	0
flatten (Flatten)	(None, 1600)	0
dense (Dense)	(None, 128)	204,928
dropout (Dropout)	(None, 128)	0
dense_1 (Dense)	(None, 10)	1,290

Total params: 225,034 (879.04 KB)
Trainable params: 225,034 (879.04 KB)
Non-trainable params: 0 (0.00 B)

```
# Step 6: Compile and Train the Model
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
history = model.fit(x_train, y_train_cat, epochs=5, batch_size=128, validation_split=0.1)
```

```
# Step 7: Evaluate the Model
loss, accuracy = model.evaluate(x_test, y_test_cat)
print(f"Test Accuracy: {accuracy:.4f}")

# Plot training history
plt.plot(history.history['accuracy'], label='Train')
plt.plot(history.history['val_accuracy'], label='Validation')
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```

```
# Step 8: Confusion Matrix
y_pred = model.predict(x_test)
y_pred_labels = np.argmax(y_pred, axis=1)
conf_matrix = confusion_matrix(y_test, y_pred_labels)

plt.figure(figsize=(10,8))
sns.heatmap(conf_matrix, annot=True, fmt="d", cmap="Blues")
plt.title("Confusion Matrix")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()

print(classification_report(y_test, y_pred_labels))
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step
```

Confusion Matrix

```
# Step 9: Save the Model (optional for deployment)
model.save("mnist_digit_recognition_model.h5")
print("Model saved successfully.")
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is c
Model saved successfully.
```