first we want to read the files

Design and implement a CNN model for digit recognition application

```
import pandas as pd
```

Double-click (or enter) to edit

```
train_data_dir  = 'train.csv'
test_data_dir  = 'test.csv'
```

```
train_data = pd.read_csv(train_data_dir)
test_data = pd.read_csv(test_data_dir)
```

```
train_data.head()
```

	label	pixel0	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	.
0	1	0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	0	0	
2	1	0	0	0	0	0	0	0	0	0	
3	4	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	

5 rows × 785 columns

Now we want to see some images in the train file

```
import numpy as np
import matplotlib.pyplot as plt
```

Randomly select 5 rows

```
num_samples = 5
selected_rows = train_data.sample(num_samples)
```

Extract the labels and pixel values

```
labels = selected_rows['label']
pixels = selected_rows.drop(columns=['label'])
```

Reshape pixel values into 28x28 images

```
images = pixels.values.reshape(-1, 28, 28)
```

Create a figure to display the images

```
plt.figure(figsize=(12, 5))
```

```
<Figure size 1200x500 with 0 Axes>
<Figure size 1200x500 with 0 Axes>
```

Plot the images

```
for i in range(num_samples):
    plt.subplot(1, num_samples, i + 1)
```

```
        plt.imshow(images[i], cmap='copper')
        plt.title(f"Label: {labels.iloc[i]}")
        plt.axis('off')
    plt.show()
```

Now we want to Normalize and create model

```
import pandas as pd
import numpy as np
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from sklearn.model_selection import train_test_split
```

Load our CSV files again

```
train_df = pd.read_csv('train.csv')
test_df = pd.read_csv('test.csv')
```

Extract the pixel values and labels from the data

```
train_pixels = train_df.drop(columns=['label']).values
train_labels = train_df['label'].values
```

Normalize the pixel values to the range [0, 1]

```
train_pixels = train_pixels / 255.0
```

Reshape the pixel values to the appropriate shape for image data

```
train_images = train_pixels.reshape(-1, 28, 28, 1)
```

Split the data into training and validation sets

```
train_images, valid_images, train_labels, valid_labels = train_test_split(
    train_images,
    train_labels,
    test_size=0.2,
    random_state=42
)
```

Set the seed

```
tf.random.set_seed(42)
```

Create an ImageDataGenerator for data augmentation

```
train_datagen = ImageDataGenerator(rescale=1./255)
valid_datagen = ImageDataGenerator(rescale=1./255)
```

Create data generators from the preprocessed data

```
train_data = train_datagen.flow(
    x=train_images,
    y=train_labels,
```

```
    batch_size=32,
    seed=42
)
valid_data = valid_datagen.flow(
    x=valid_images,
    y=valid_labels,
    batch_size=32,
    seed=42
)
```

Create CNN model

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Conv2D(filters=10,
                         kernel_size=3,
                         activation="relu",
                         input_shape=(28, 28, 1)),
  tf.keras.layers.Conv2D(10, 3, activation="relu"),
  tf.keras.layers.MaxPool2D(pool_size=2,
                            padding="valid"),
  tf.keras.layers.Conv2D(10, 3, activation="relu"),
  tf.keras.layers.Conv2D(10, 3, activation="relu"),
  tf.keras.layers.MaxPool2D(2),
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(10, activation="softmax")
])
```

Compile the model

```
model.compile(loss="sparse_categorical_crossentropy",
              optimizer=tf.keras.optimizers.Adam(),
              metrics=["accuracy"])
```

Fit the model

```
history = model.fit(train_data,
                    epochs=5,
                    steps_per_epoch=len(train_data),
                    validation_data=valid_data,
                    validation_steps=len(valid_data))
```

```
Epoch 1/5
144/144 [==============================] - 4s 21ms/step - loss: nan - accuracy: 0.0923 - val_loss: nan - val_accuracy: 0.1081
Epoch 2/5
144/144 [==============================] - 4s 27ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 3/5
144/144 [==============================] - 3s 20ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 4/5
144/144 [==============================] - 2s 16ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 5/5
144/144 [==============================] - 2s 16ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
```

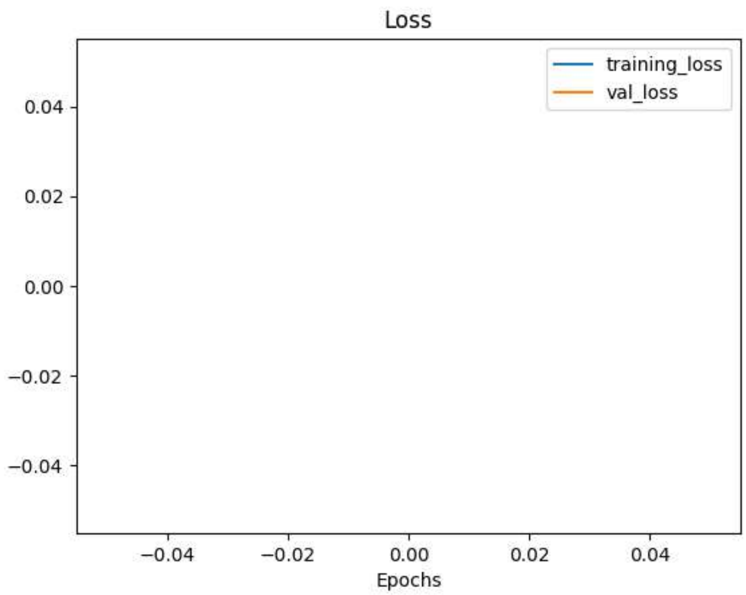
Now we want to plot training_loss, val_loss, training_accuracy and val_accuracy

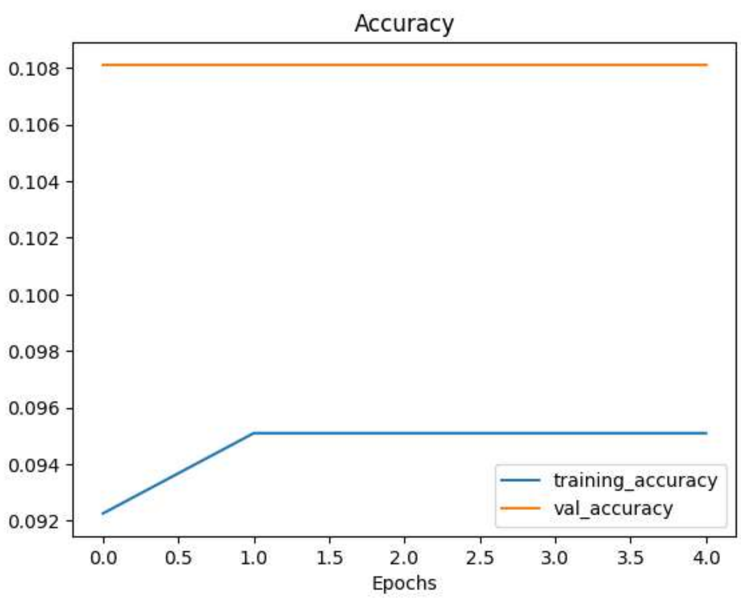
```
import matplotlib.pyplot as plt

def plot_loss_curves(history):
  """
  Returns separate loss curves for training and validation metrics.
  """
  loss = history.history['loss']
  val_loss = history.history['val_loss']

  accuracy = history.history['accuracy']
  val_accuracy = history.history['val_accuracy']

  epochs = range(len(history.history['loss']))

  # Plot loss
  plt.plot(epochs, loss, label='training_loss')
  plt.plot(epochs, val_loss, label='val_loss')
```

```
    plt.title('Loss')
    plt.xlabel('Epochs')
    plt.legend()

    # Plot accuracy
    plt.figure()
    plt.plot(epochs, accuracy, label='training_accuracy')
    plt.plot(epochs, val_accuracy, label='val_accuracy')
    plt.title('Accuracy')
    plt.xlabel('Epochs')
    plt.legend();
```

Check out the loss curves of model

```
plot_loss_curves(history)
```





Now we want to predict on test data

Preprocess the test data

```
test_pixels = test_df.values / 255.0  # Normalize the pixel values
test_images = test_pixels.reshape(-1, 28, 28, 1)
```

Use the trained model to make predictions

```
predictions = model.predict(test_images)
```

```
162/162 [==============================] - 1s 5ms/step
```

Convert the predicted probabilities to class labels

```
predicted_labels = np.argmax(predictions, axis=1)
```

Convert the predicted labels to a DataFrame with 'ImageId' and 'Label' columns

```
image_ids = range(1, len(predicted_labels) + 1)
submission_df = pd.DataFrame({'ImageId': image_ids, 'Label': predicted_labels})
```

Save the DataFrame to a CSV file

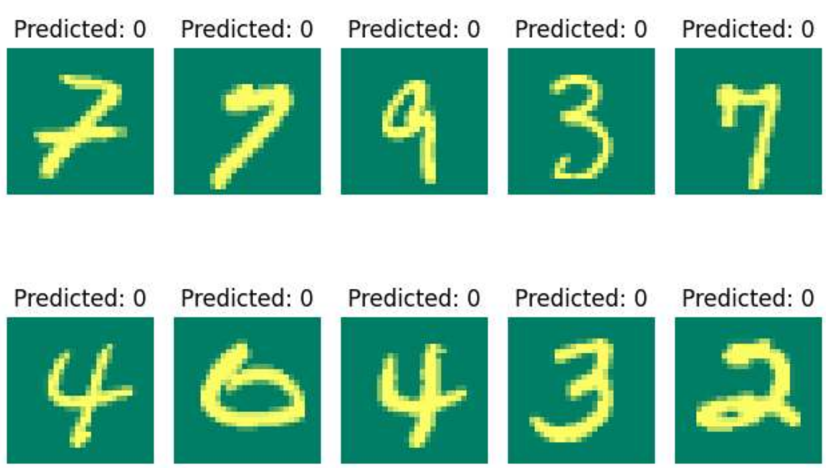
```
submission_df.to_csv('submission.csv', index=False)
```

Because of we don't have the actual labels for the test data, we won't be able to calculate traditional evaluation metrics like accuracy, precision, recall, or F1-score, as these metrics require a ground truth for comparison.

However, we can still get an idea of how well your model is performing on the test data by doing ***Visual Inspection***

Visual Inspection: Take a look at some of the predicted labels and corresponding images to get a qualitative sense of the model's performance. We can use matplotlib to display the images and predicted labels.

```
import matplotlib.pyplot as plt

# Display some random test images with their predicted labels
num_samples_to_display = 10
random_indices = np.random.choice(len(predicted_labels), num_samples_to_display, replace=False)

for i, idx in enumerate(random_indices):
    plt.subplot(2, 5, i + 1)
    plt.imshow(test_images[idx].reshape(28, 28), cmap='summer')
    plt.title(f'Predicted: {predicted_labels[idx]}')
    plt.axis('off')

plt.tight_layout()
plt.show()
```



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